US008317815B2

(12) **United States Patent**
Mastri et al.

(10) **Patent No.: US 8,317,815 B2**
(45) **Date of Patent: Nov. 27, 2012**

(54) **VISUALIZATION TROCAR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 311 days.

(21) Appl. No.: **11/973,123**

(22) Filed: **Oct. 5, 2007**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 60/850,006, filed on Oct. 6, 2006, provisional application No. 60/923,921, filed on Apr. 17, 2007.

(51) **Int. Cl.**
A61B 17/00 (2006.01)

(52) **U.S. Cl.** **606/190**; 606/185

(58) **Field of Classification Search** 606/185, 606/190; 604/264, 272, 273, 274, 284; 600/184
See application file for complete search history.

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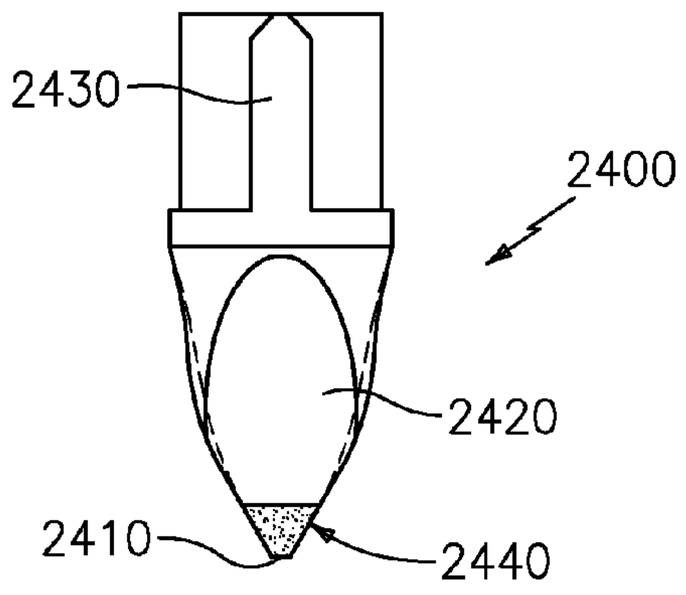
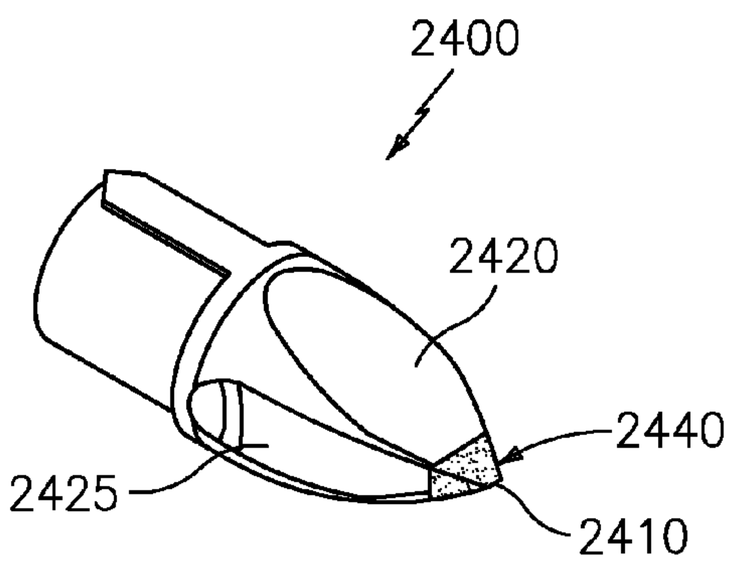
(57) **ABSTRACT**

A surgical trocar and penetrating tip therefor are provided. The tip includes a generally transparent body having proximal and distal ends and an opaque distal tip portion, an integral penetrating edge arranged at a distal end of the body, and inwardly tapered opposed facets formed on the body, converging with one another at the integral penetrating edge.

24 Claims, 18 Drawing Sheets





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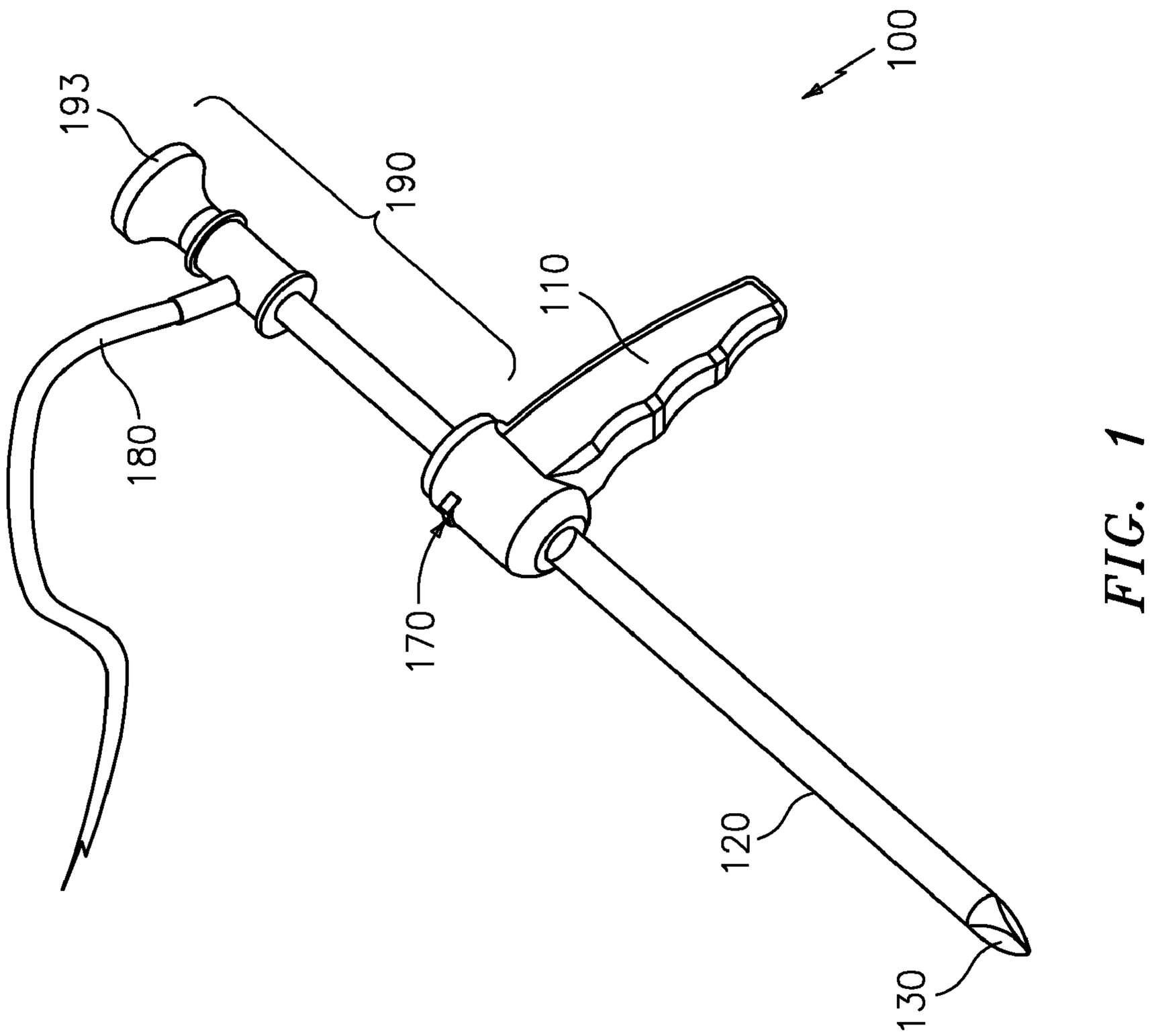

FIG. 1

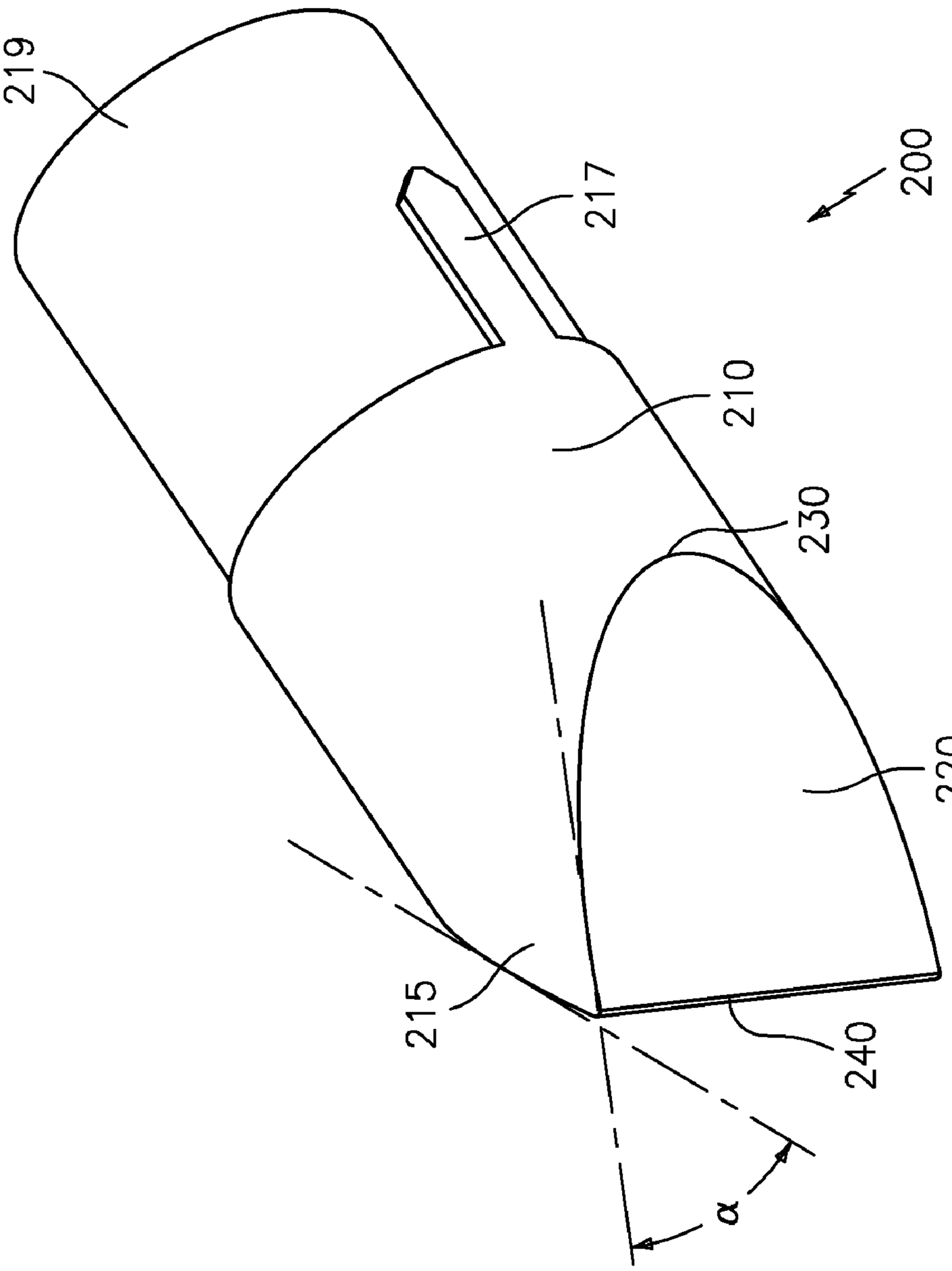

FIG. 2

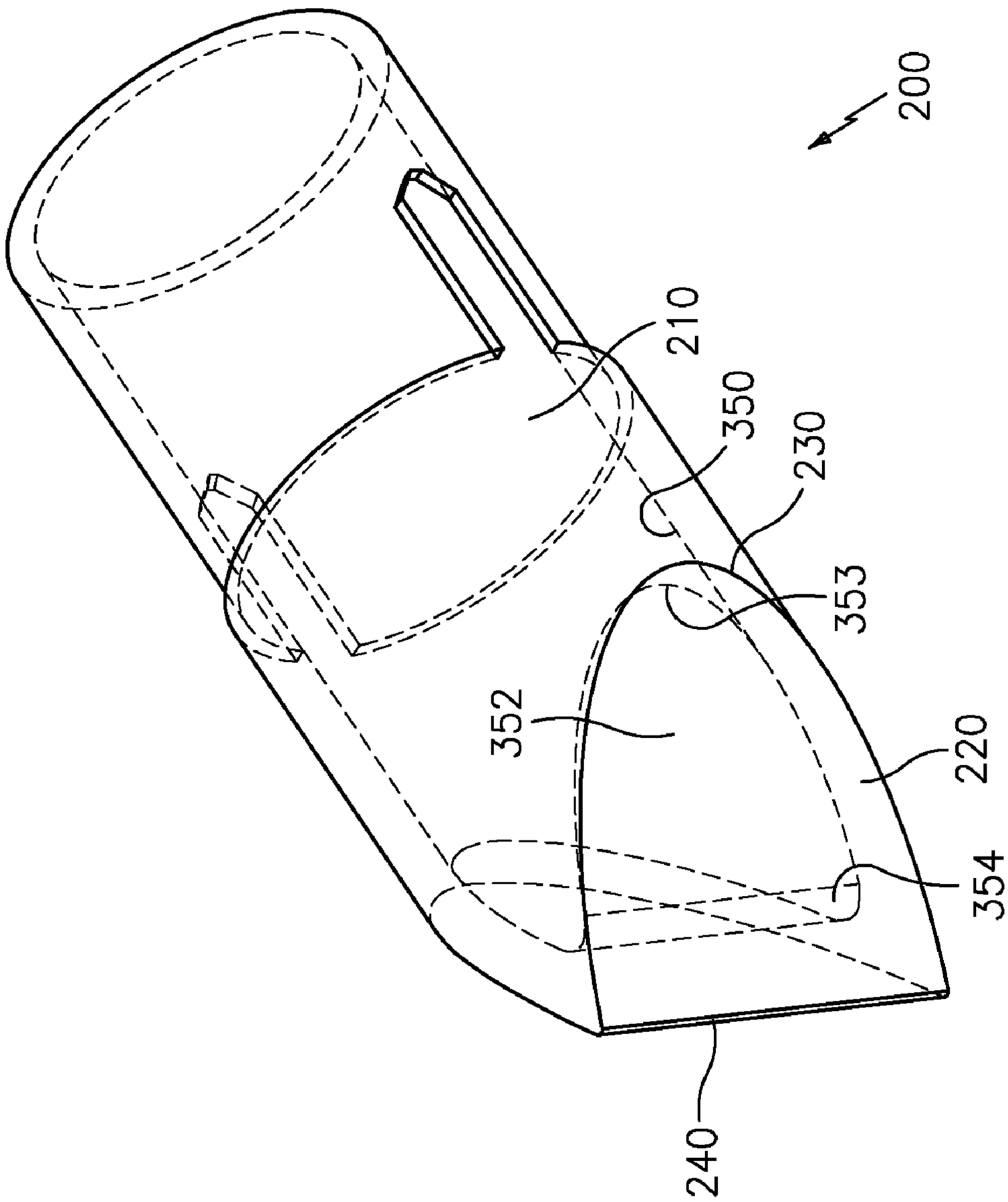

FIG. 3

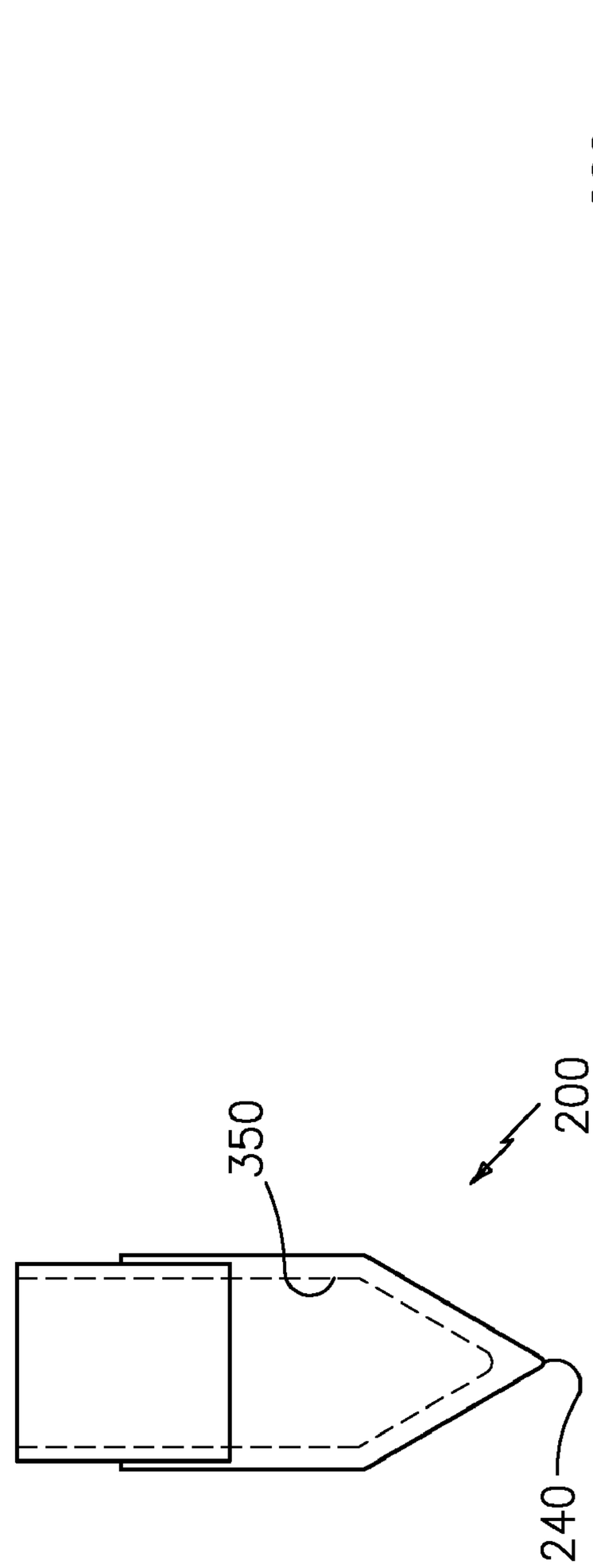

FIG. 6

FIG. 4

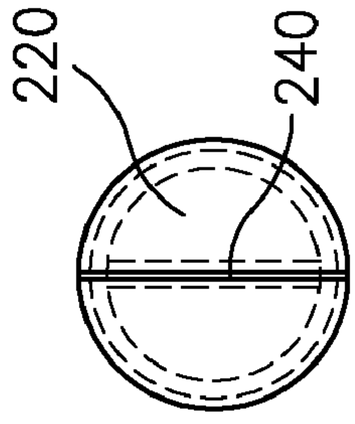

FIG. 5

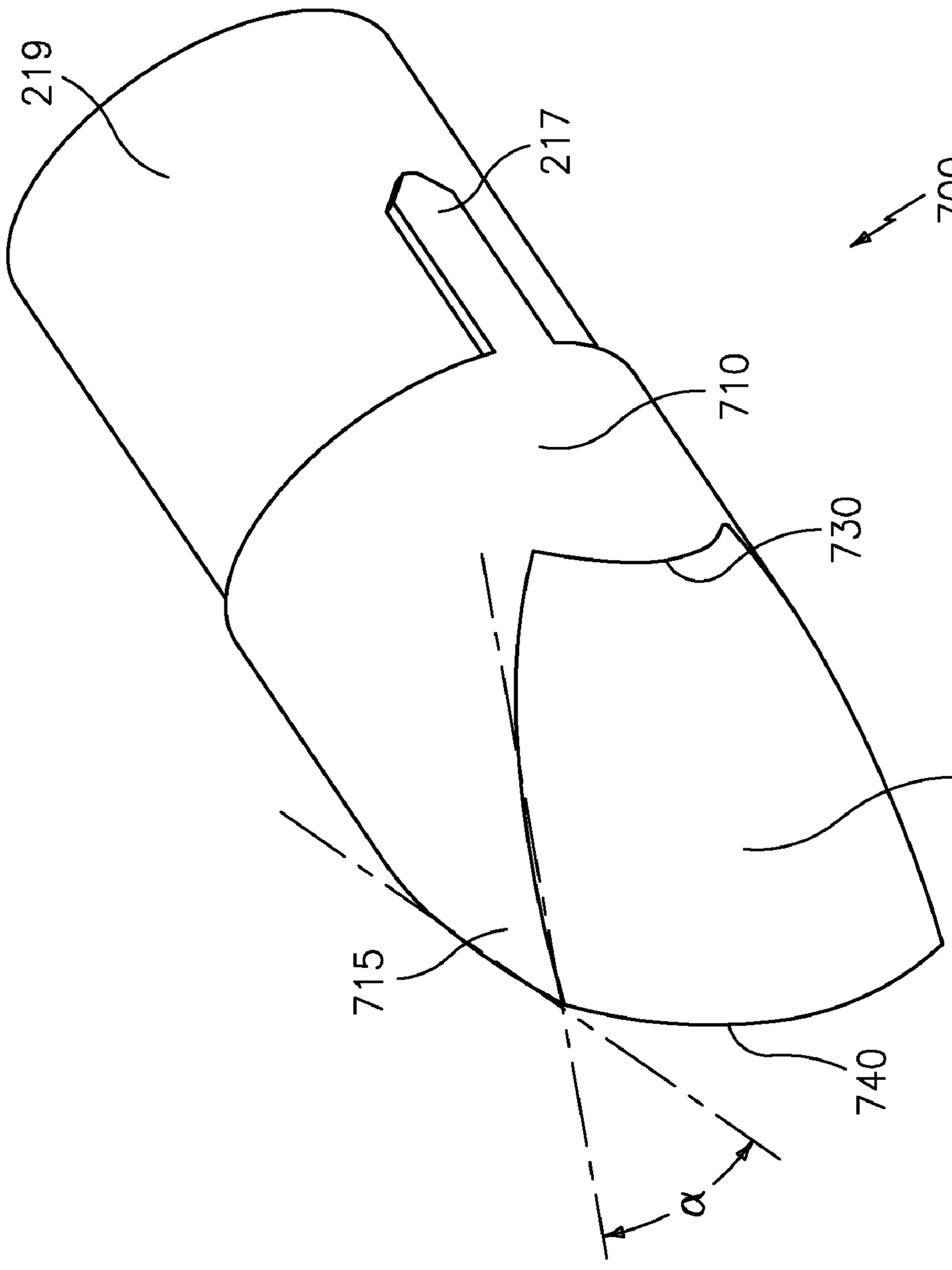

FIG. 7

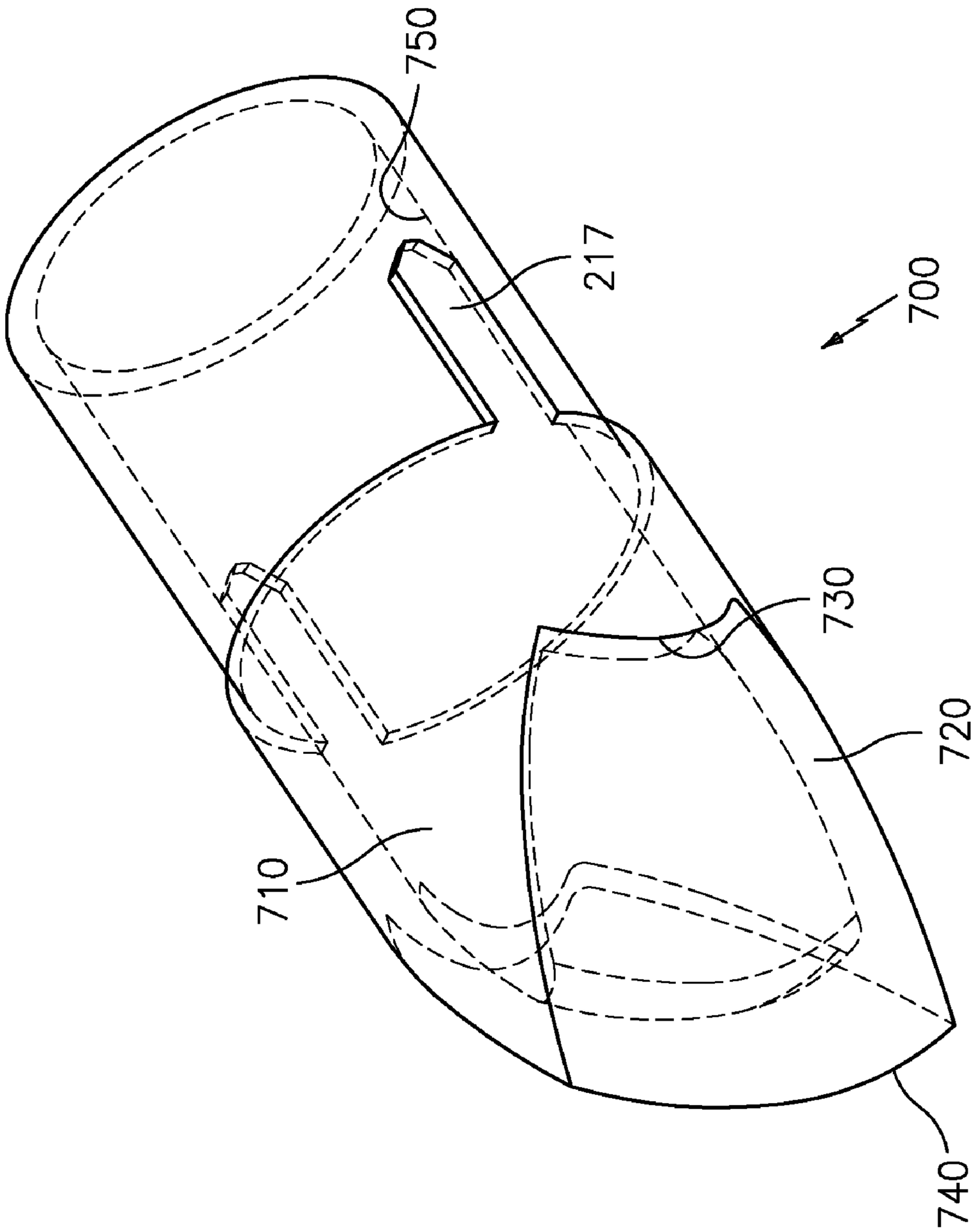

FIG. 8

FIG. 9

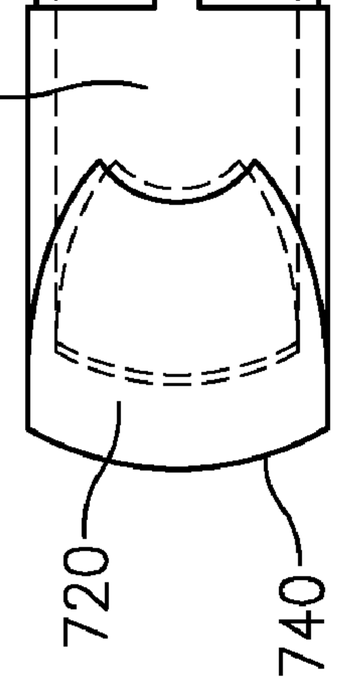

FIG. 10

FIG. 11

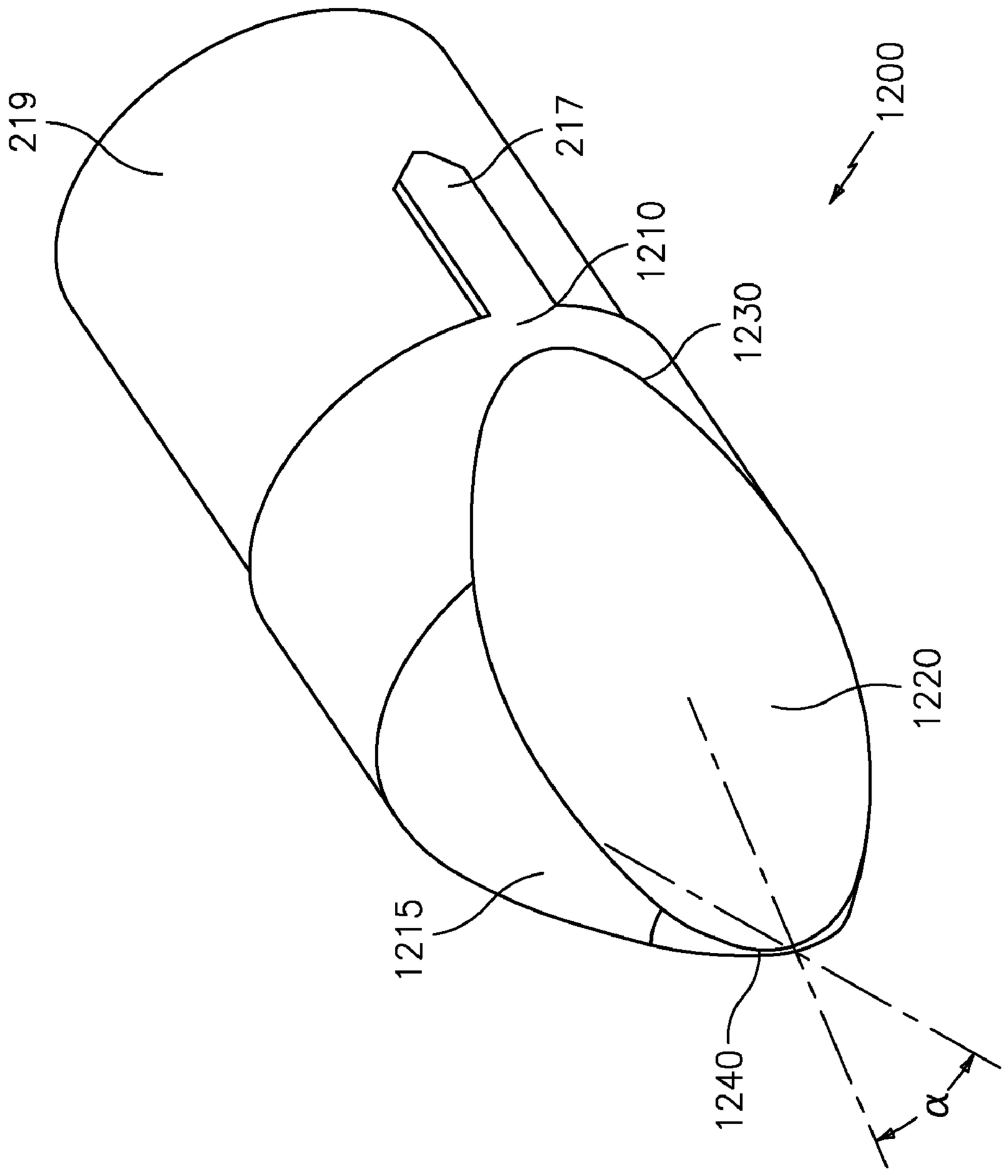

FIG. 12

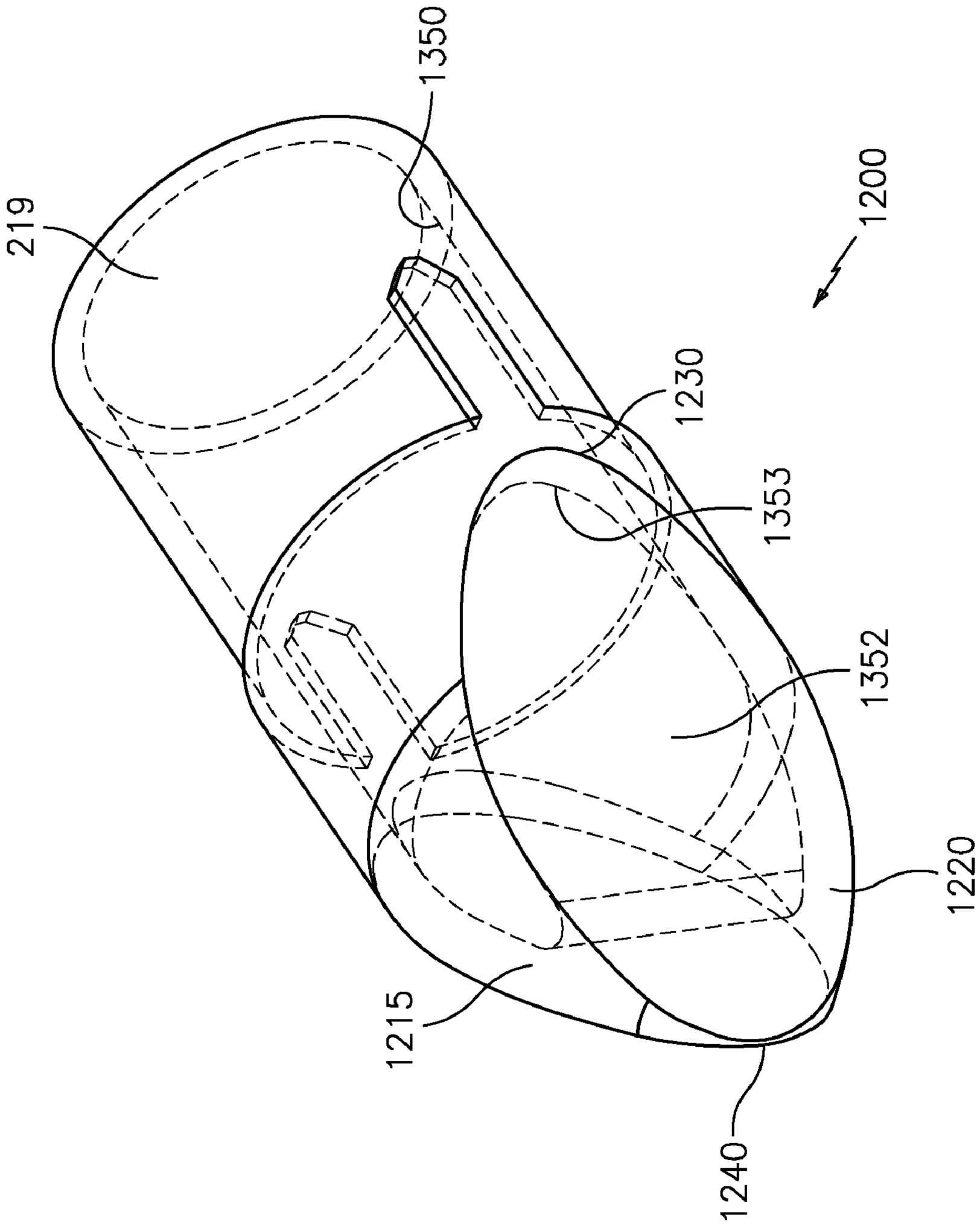

FIG. 13

FIG. 14

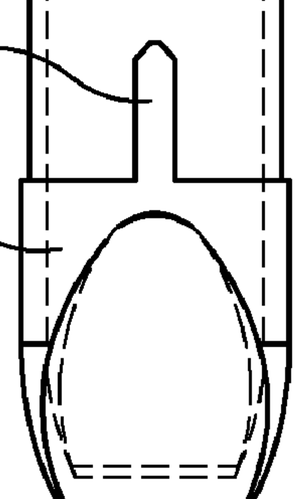

FIG. 15

FIG. 16

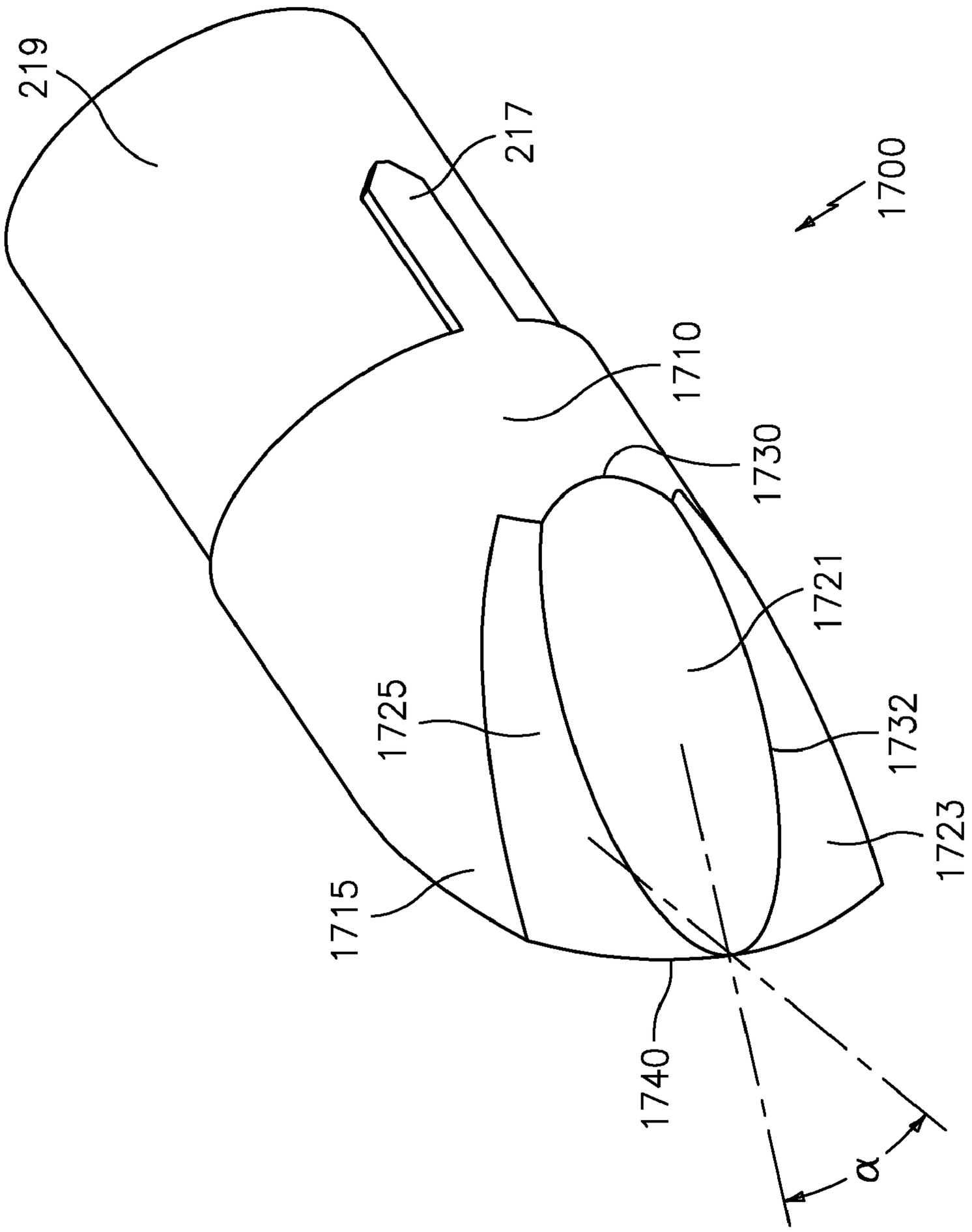

FIG. 17

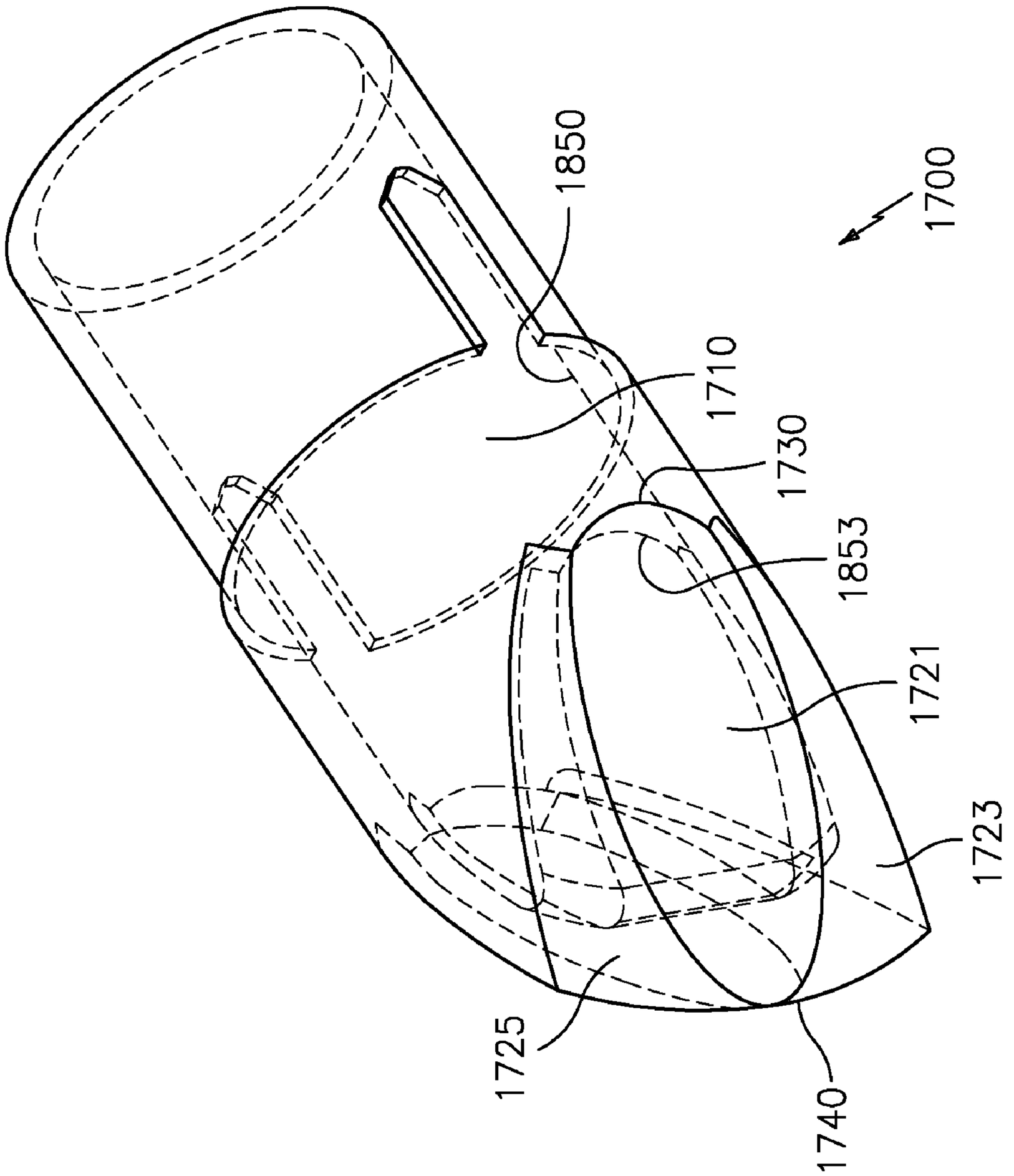

FIG. 18

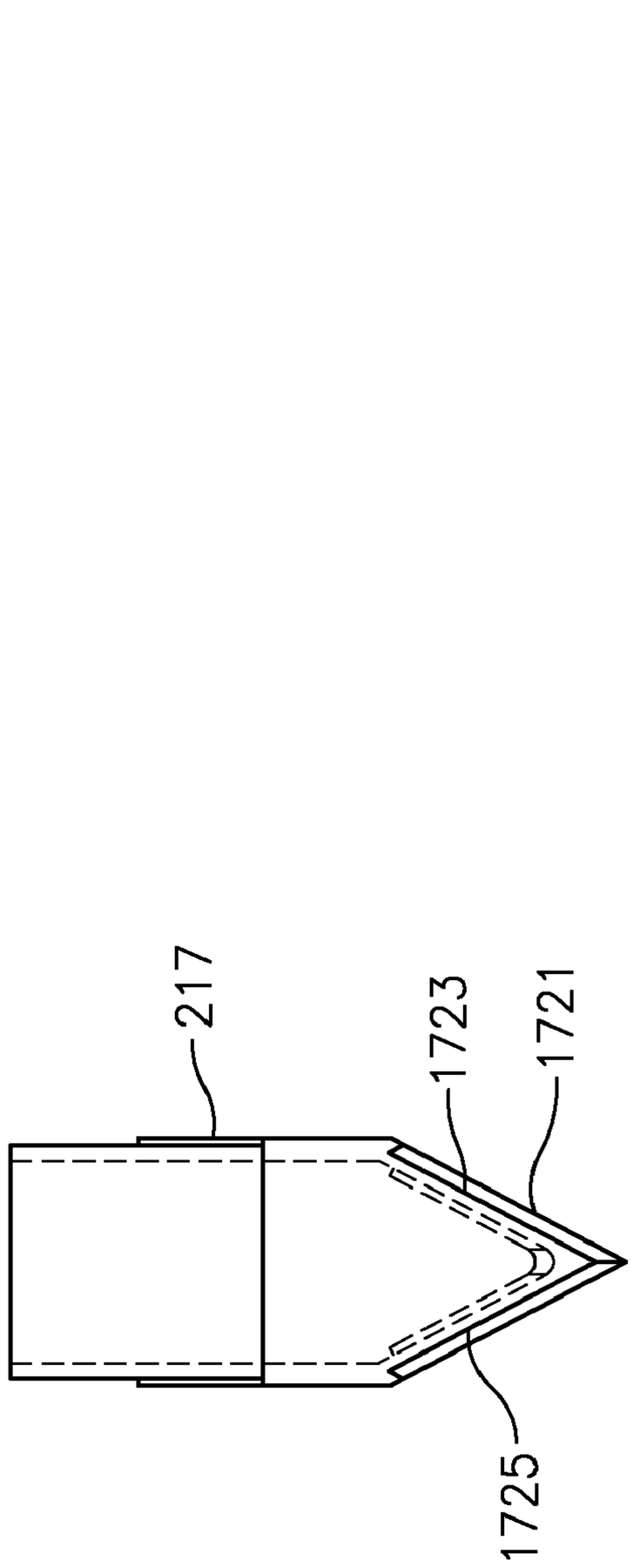

FIG. 19

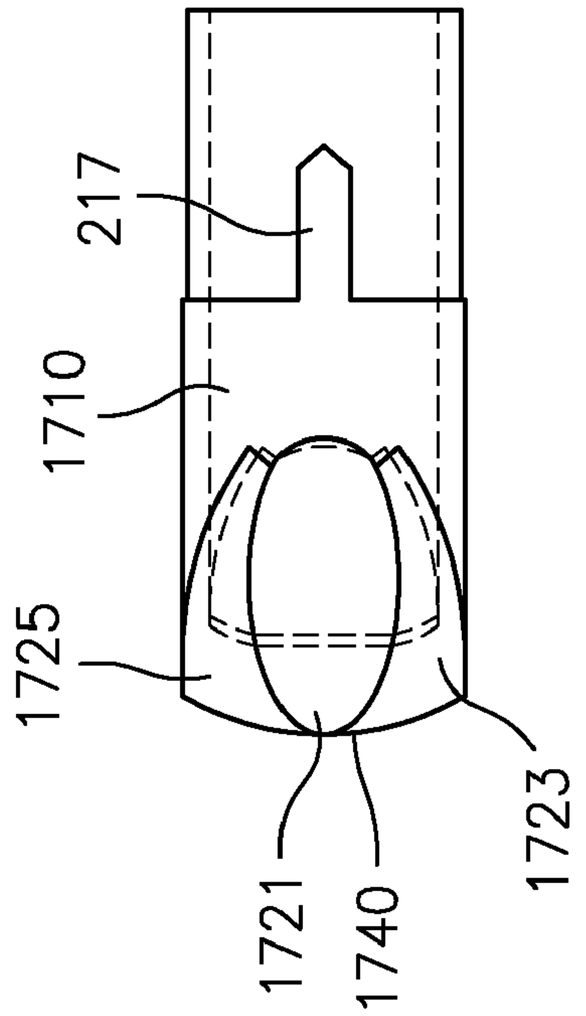

FIG. 21

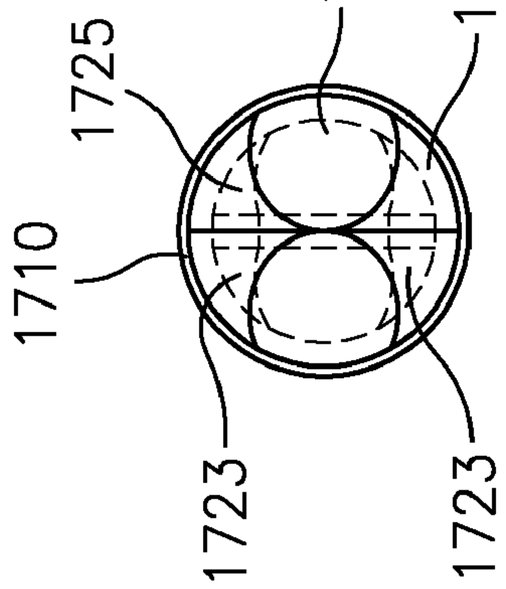

FIG. 20

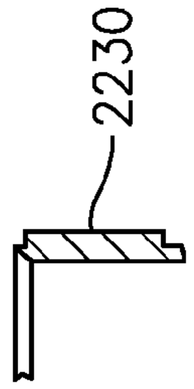

FIG. 22F

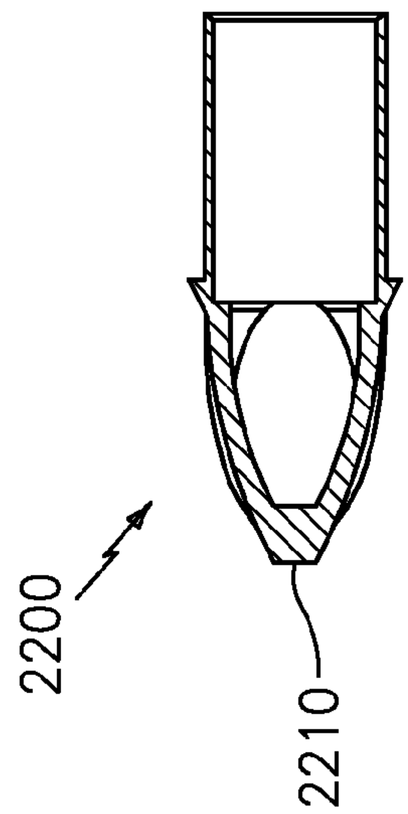

FIG. 22D

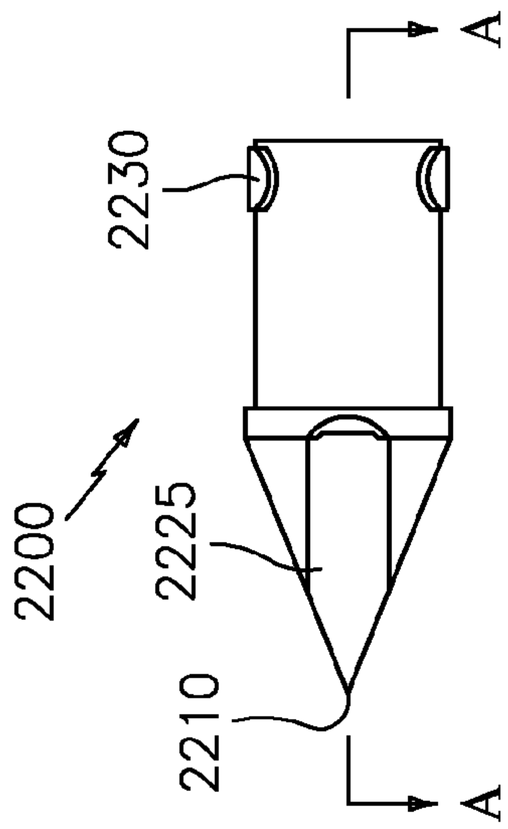

FIG. 22C

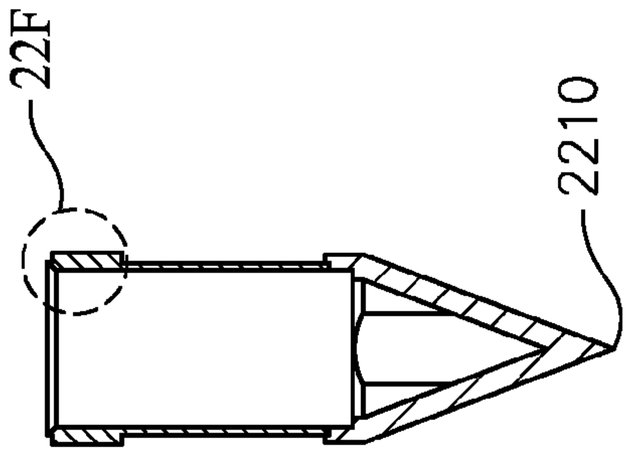

FIG. 22E

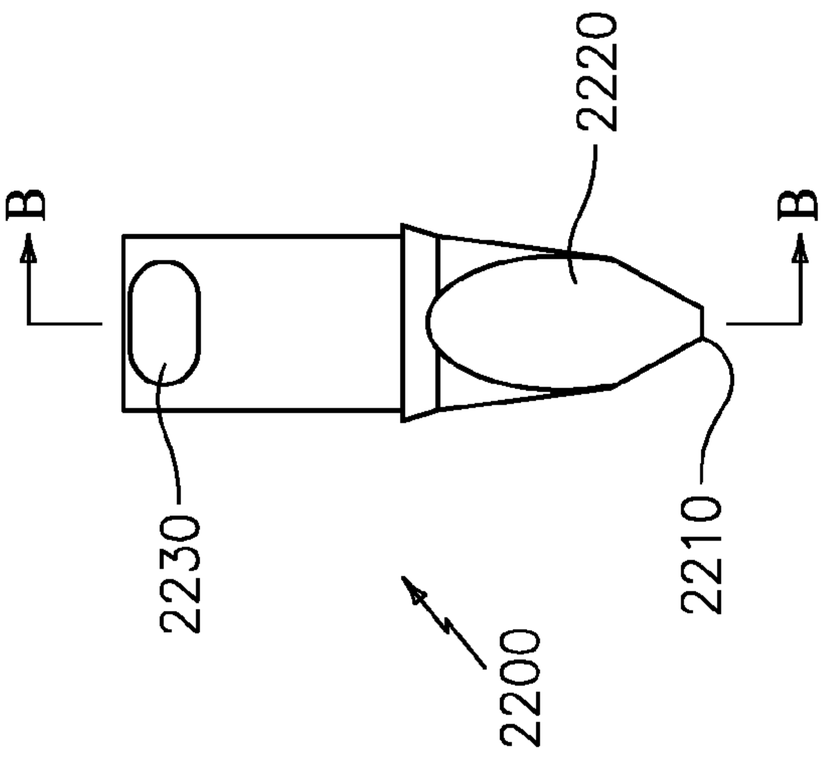

FIG. 22A

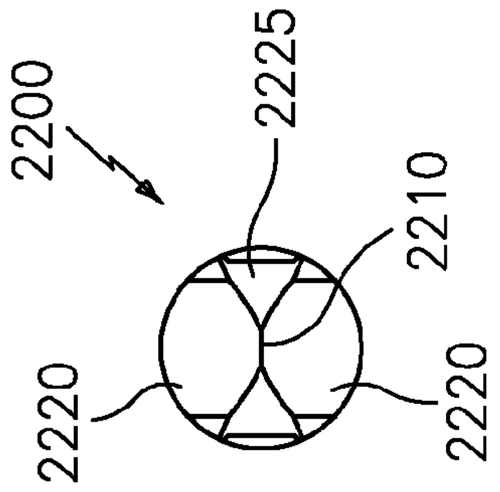

FIG. 22B

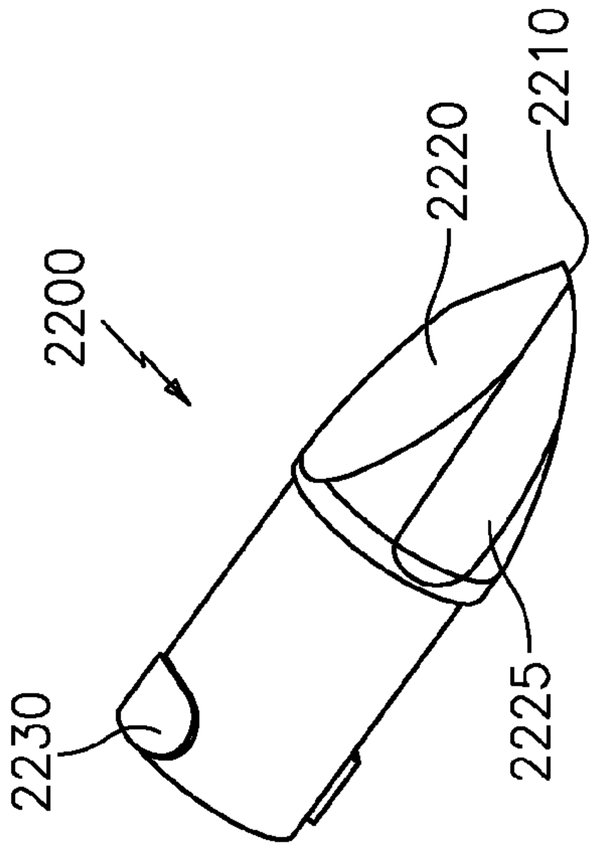

FIG. 23D

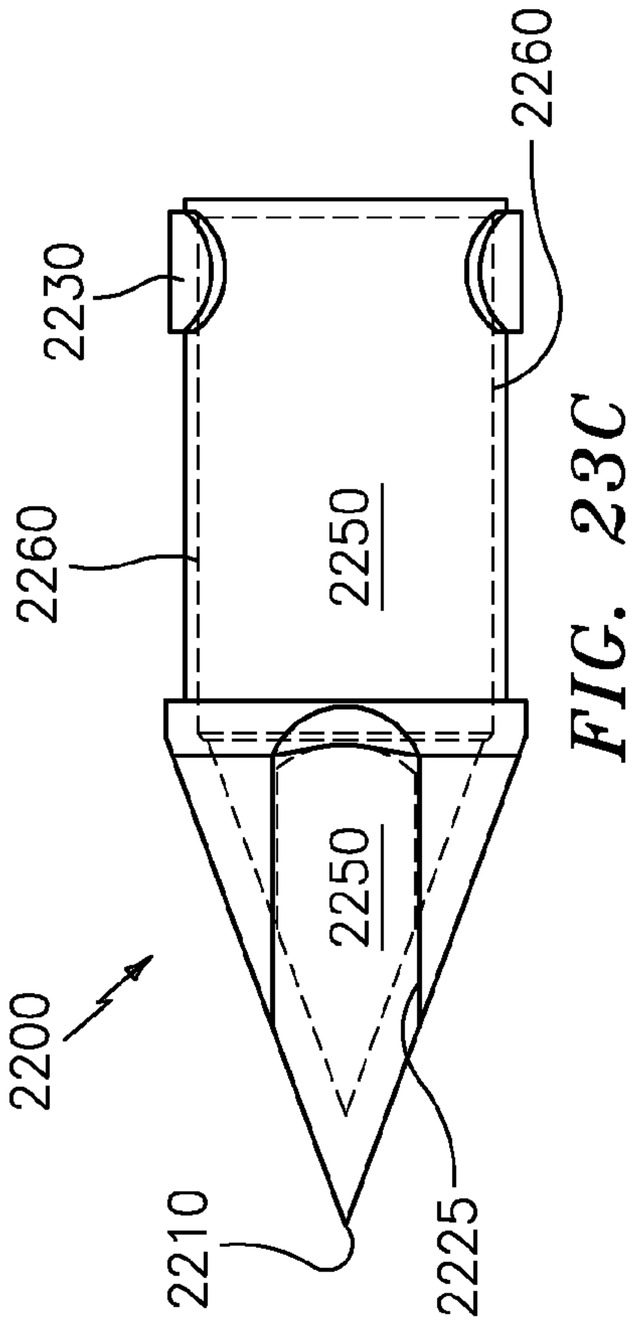

FIG. 23C

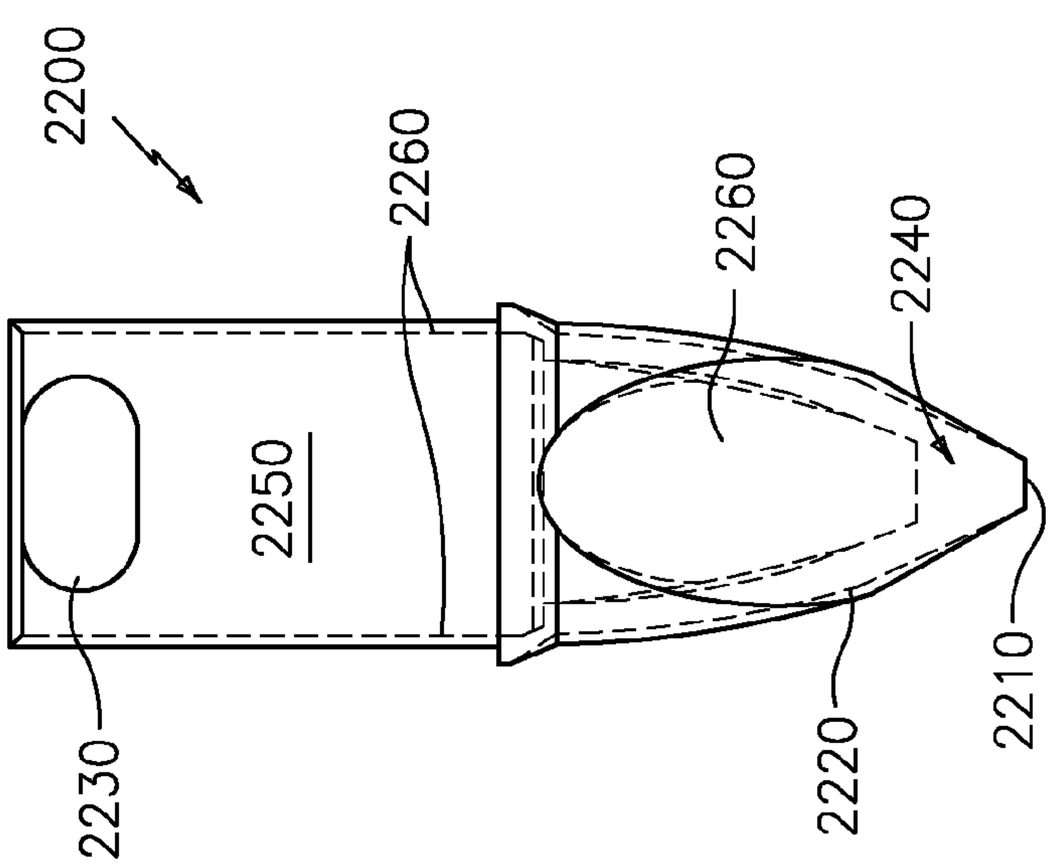

FIG. 23A

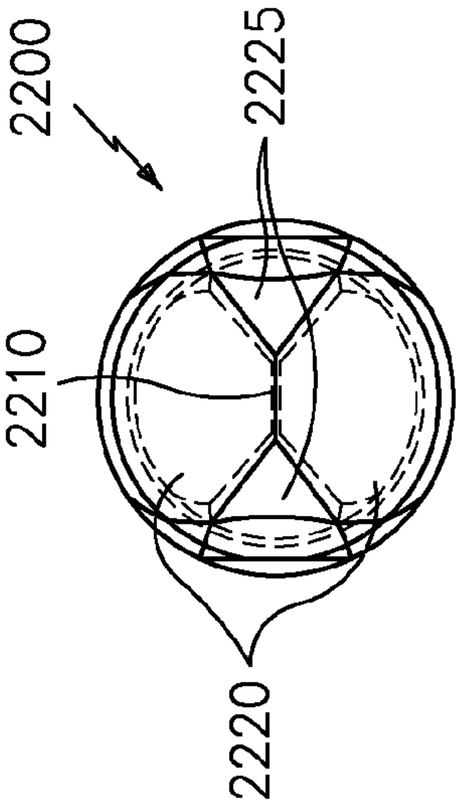

FIG. 23B

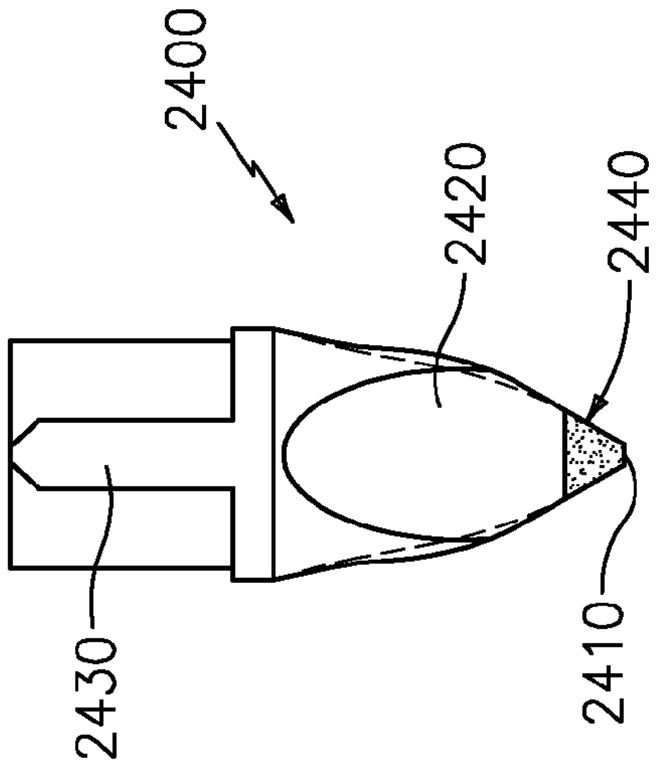

FIG. 24A

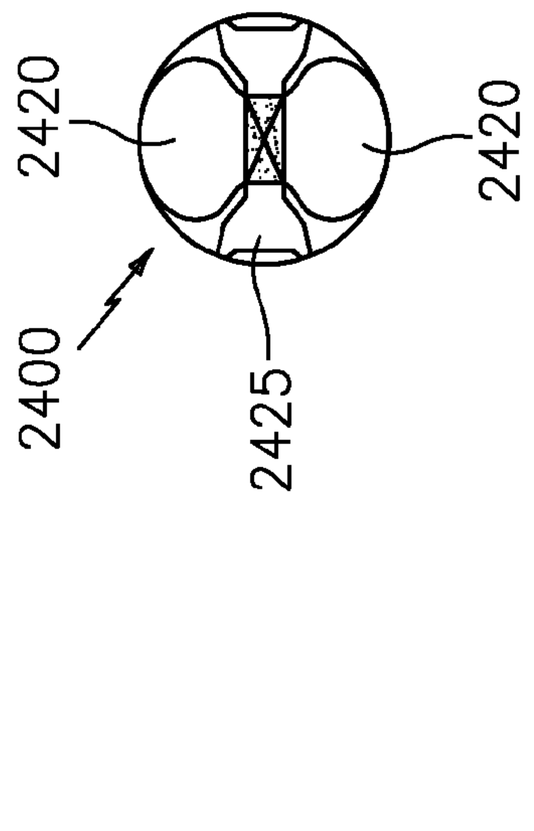

FIG. 24D

FIG. 24B

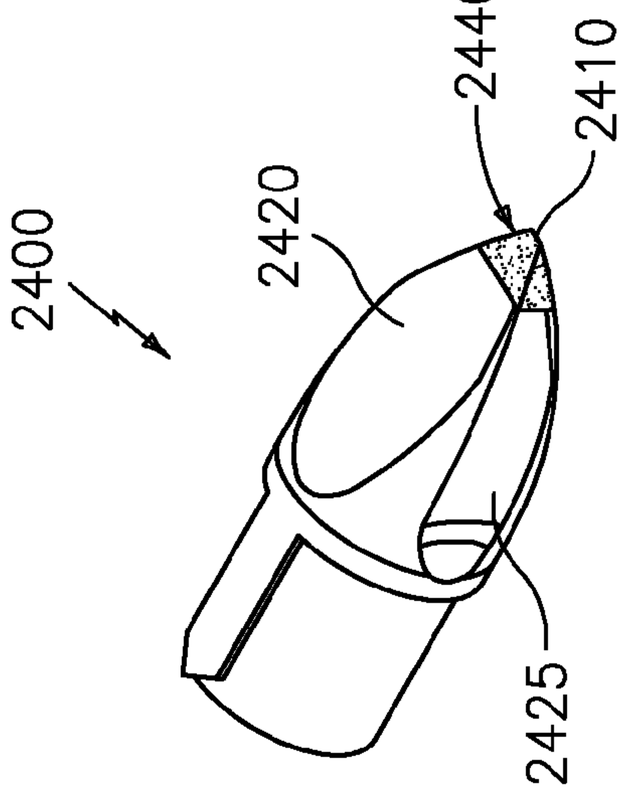

FIG. 24C

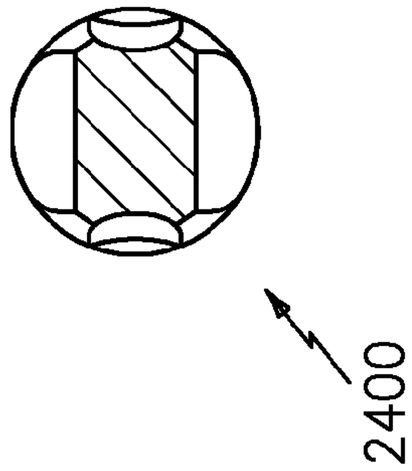

FIG. 24E

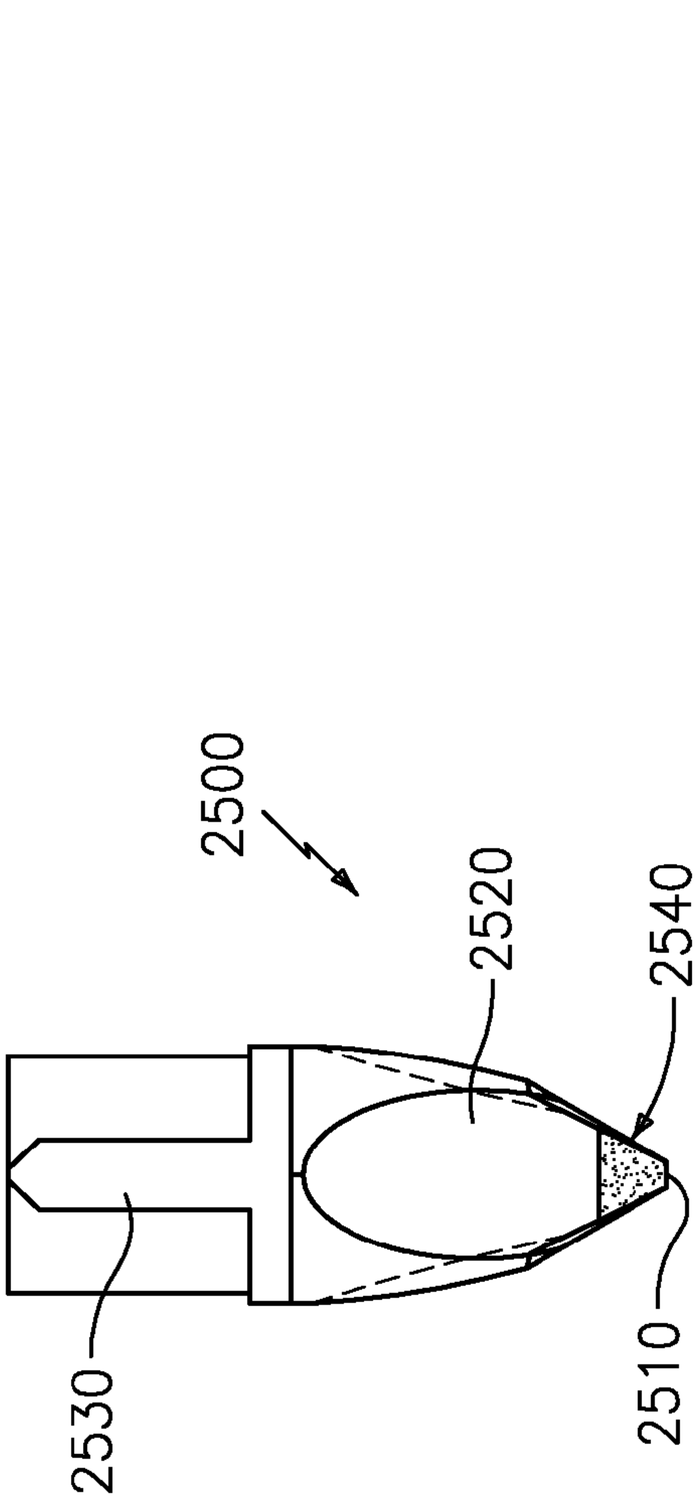

FIG. 25A

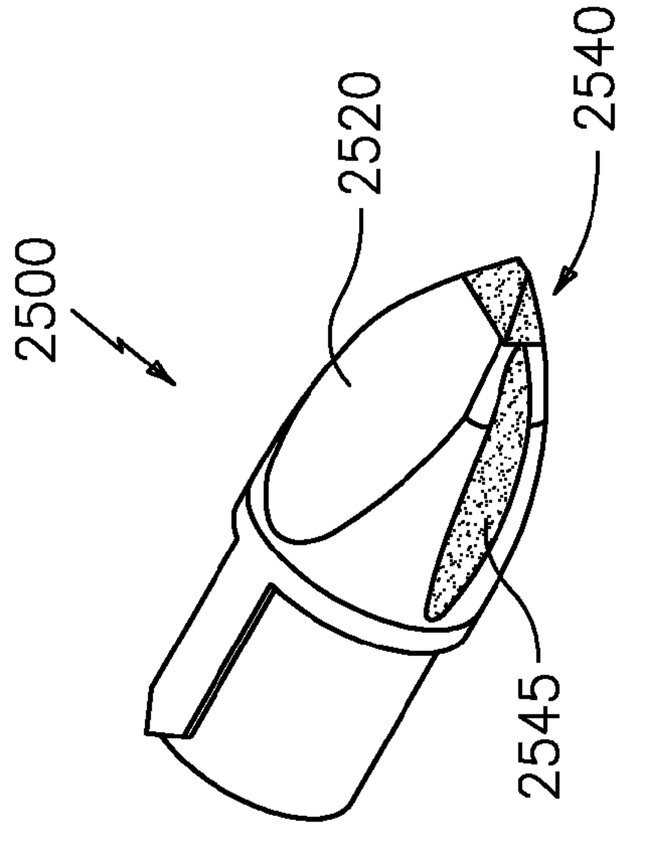

FIG. 25C

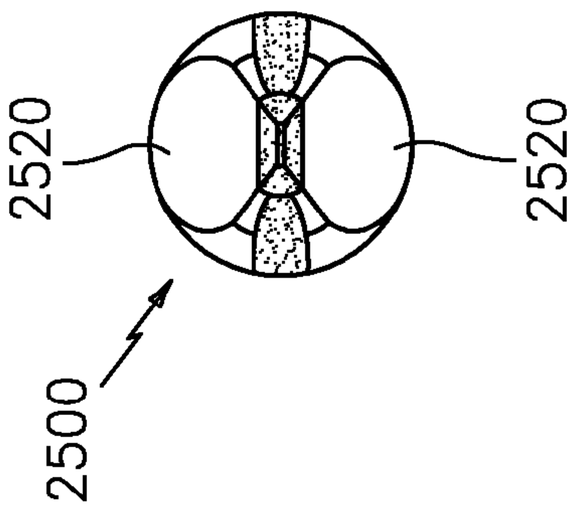

FIG. 25B

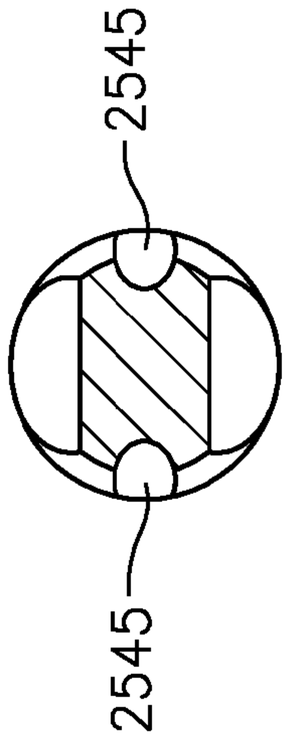

FIG. 25E

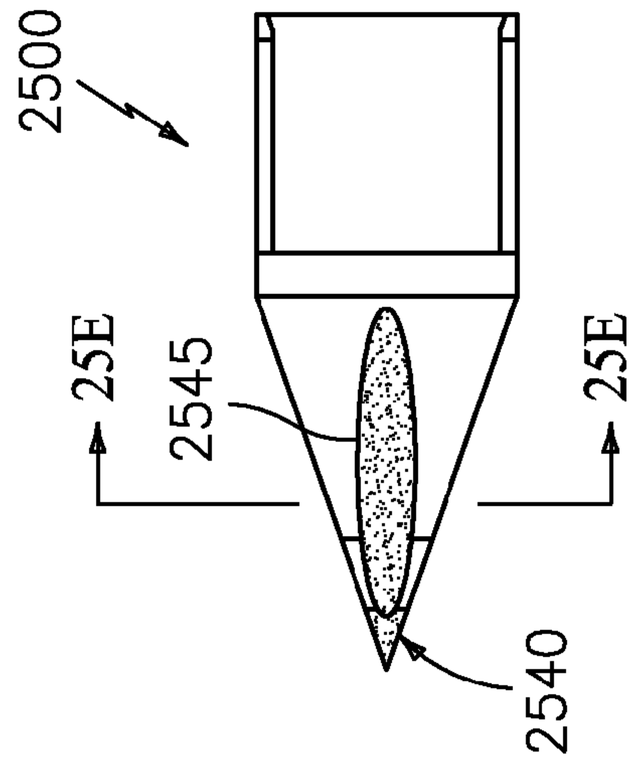

FIG. 25D

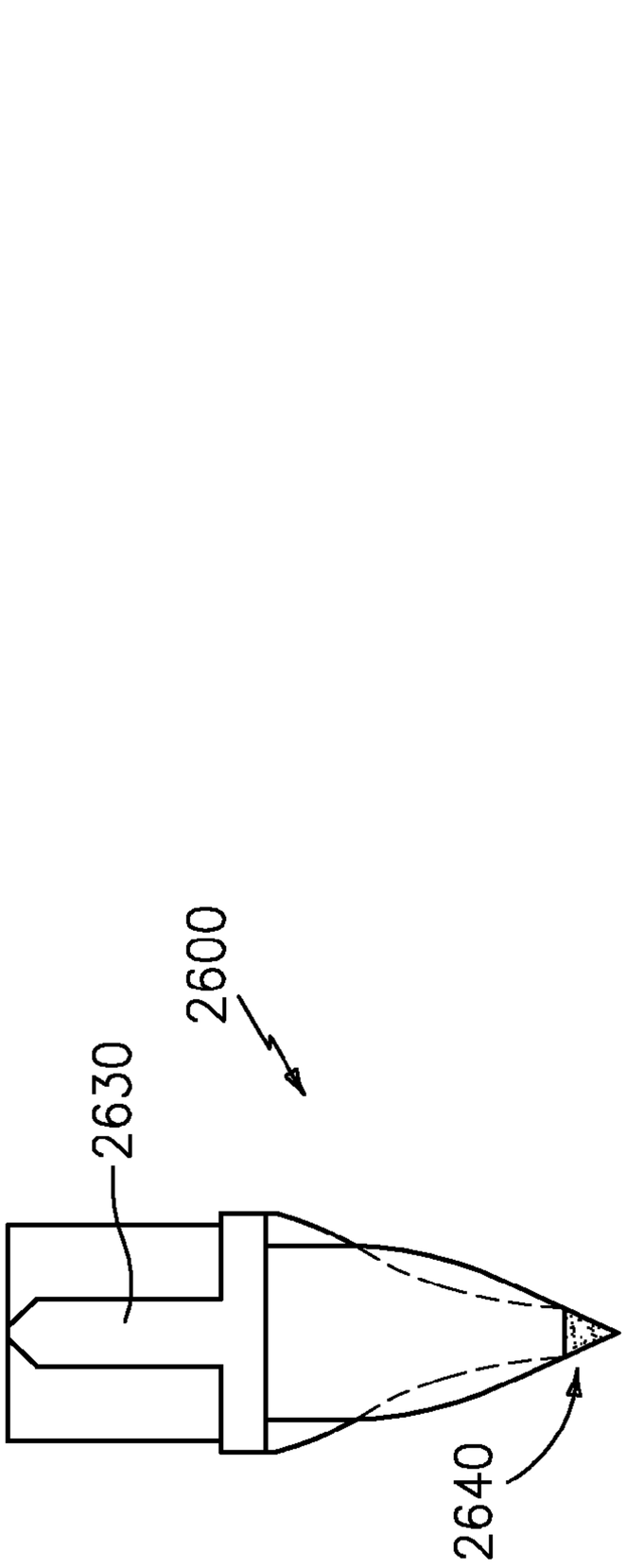

FIG. 26A

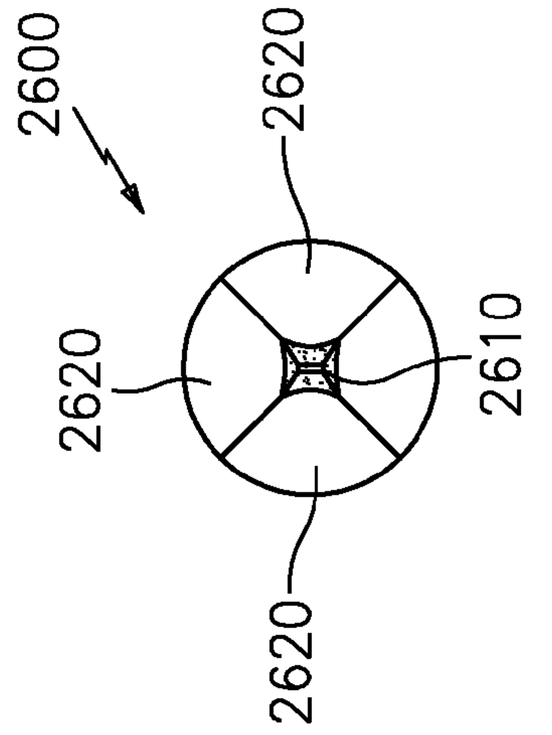

FIG. 26B

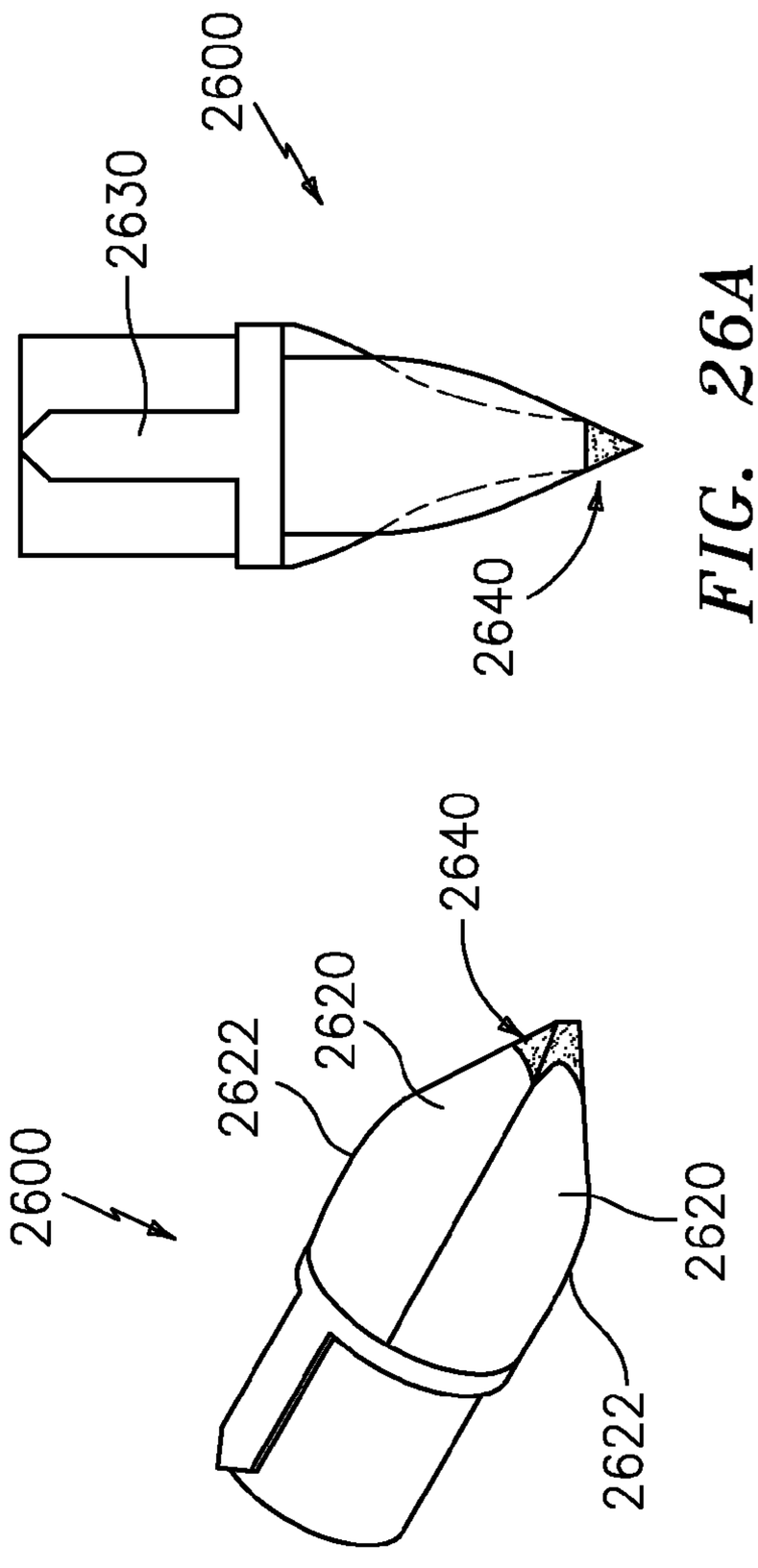

FIG. 26C

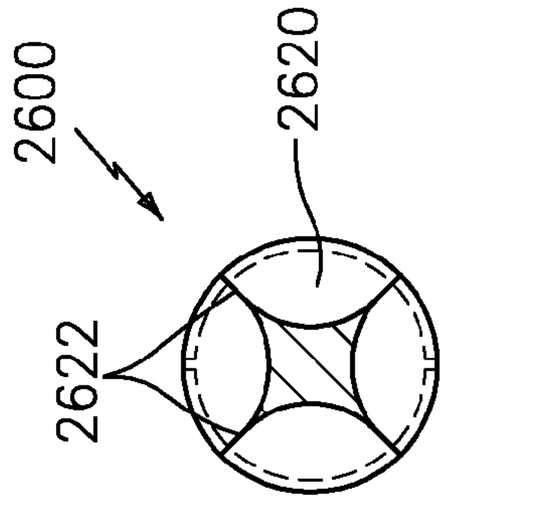

FIG. 26E

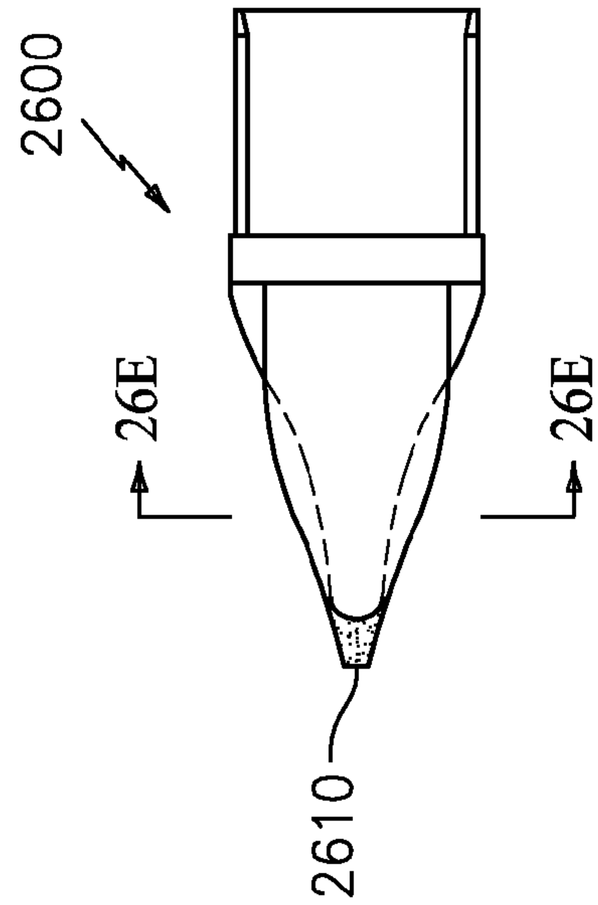

FIG. 26D

VISUALIZATION TROCAR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 60/923,921 filed Apr. 17, 2007 and to U.S. Provisional Application No. 60/850,006 filed Oct. 6, 2006. Each of the foregoing provisional applications is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to surgical instruments such as trocars for use in insertion of surgical access devices, such as access cannulas. Particularly, the present invention is directed to such insertion devices having a transparent tip to allow visualization of tissue being penetrated.

2. Description of Related Art

A variety of devices and methods are known in the art for insertion of surgical access devices, such as surgical cannulas in minimally-invasive surgical procedures. Of such devices, many are configured to puncture a patient's abdominal wall. Most of such insertion devices are fully solid and opaque, so a surgeon cannot easily visually differentiate between layers of the abdominal wall and internal abdominal organs.

Some insertion devices have been developed that include a transparent tip or an integral endoscope While such devices can offer improved guidance to a surgeon over those with no means for visualization, such devices can be relatively complex, difficult to manufacture, and therefore can be expensive. Accordingly, there still remains a need in the art for an insertion device that is capable of visually guiding puncture of an abdominal wall and, optionally, concurrent insertion of a surgical access device. There further remains a need for such a device that is relatively inexpensive and easy to fabricate. The present invention provides a solution for these foregoing problems.

SUMMARY OF THE INVENTION

The purpose and advantages of the present invention will be set forth in and apparent from the description that follows. Additional advantages of the invention will be realized and attained by the methods and systems particularly pointed out in the written description and claims hereof, as well as from the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the invention, as embodied, includes a penetrating tip for a surgical trocar. The penetrating tip includes a generally transparent body, having proximal and distal ends. The body has an opaque distal tip portion, which can be used as a guide or indicator, and/or to reduce glare, as described in more detail below. The body also has an integral penetrating edge arranged at a distal end of the body, and inwardly tapered opposed facets formed in the body, converging with one another at the integral penetrating edge, which can be a dissecting edge, a cutting edge or a blunt edge, for example. Alternatively, the penetrating edge is arranged on the tip in the distal end portion thereof, and not necessarily at the distal end thereof.

In accordance with the invention, the tip can further include an expanded-diameter region for engaging a surgical access device. The tip can be formed by molding, such as by injection molding. The tip's opposed facets can be convexly curved, substantially planar, or a combination thereof.

Opposed facets are provided on the tip at a predetermined angle with respect to one another, such as at 20 degrees or 30 degrees. In other embodiments in accordance with the invention, the facets are provided at an angle of about 40 degrees, with respect to one another. It is therefore to be understood that a relative angle of between about 5 and about 90 degrees, at any increment of one-degree therebetween may be used for tips in accordance with the invention.

In accordance with the invention, the penetrating edge of the tip can be substantially straight or convexly arcuate in configuration. If desired, a locking element can be provided on the body for engaging a trocar or other insertion device. Tips in accordance with the invention can further include an inner optical surface configured so as to minimize distortion of images taken through the penetrating tip. The tips can be formed of a plastic material, which can be, for example, polycarbonate plastic or polymethyl methacrylate.

In accordance with another aspect of the invention, a surgical trocar is provided having a handle, a shaft extending from the handle and a penetrating tip. The penetrating tip includes a generally transparent body having proximal and distal ends. The body has an opaque distal tip portion, an integral penetrating edge arranged at a distal end of the body, and inwardly tapered opposed facets formed in the body, converging with one another at the integral penetrating edge. The trocar can further include an optical path extending from the tip to an imaging device. The imaging device can be, for example, a CCD sensor or an optical eyepiece. Further, the imaging device can be provided in the shaft of the surgical trocar or external thereto. In accordance with a further aspect of the invention, the trocar can further include an access device, configured and dimensioned to receive the shaft of the trocar.

In accordance with still another aspect of the invention, a kit is provided having a package for holding kit contents and storing kit contents in a sterile environment, a surgical trocar and one or more penetrating tips for the surgical trocar. The surgical trocar has a handle, and a shaft extending from the handle. The penetrating tips for the surgical trocar each have a generally transparent body having proximal and distal ends. The body has an opaque distal tip portion, and an integral edge arranged at a distal end of the body and inwardly tapered opposed facets formed in the body, converging with one another at the integral edge.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and are intended to provide further explanation of the invention claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute part of this specification, are included to illustrate and provide a further understanding of the invention. Together with the description, the drawings serve to explain the principles of the invention, wherein:

FIG. **1** is an isometric view of an exemplary embodiment of a trocar in accordance with the present invention, for use with penetrating tips constructed in accordance with the invention;

FIG. **2** is an isometric view of one embodiment of a penetrating tip in accordance with the invention, which includes a substantially straight edge;

FIG. **3** is an isometric view of the penetrating tip of FIG. **2**, including hidden lines illustrating internal surface geometry of the tip;

FIG. **4** is a side view of the penetrating tip of FIG. **2**, including hidden lines illustrating internal surface geometry;

FIG. **5** is an end view of the penetrating tip of FIG. **2**, including hidden lines illustrating internal surface geometry;

FIG. **6** is a top view of the penetrating tip of FIG. **2**, including hidden lines illustrating internal surface geometry;

FIG. **7** is an alternate embodiment of a penetrating tip in accordance with the invention, having an arcuate penetrating surface;

FIG. **8** is an isometric view of the penetrating tip of FIG. **7**, including hidden lines illustrating internal surface geometry of the tip;

FIG. **9** is a side view of the penetrating tip of FIG. **7**, including hidden lines illustrating internal surface geometry;

FIG. **10** is an end view of the penetrating tip of FIG. **7**, including hidden lines illustrating internal surface geometry;

FIG. **11** is a top view of the penetrating tip of FIG. **7**, including hidden lines illustrating internal surface geometry;

FIG. **12** is a further embodiment of a penetrating tip in accordance with the invention having ovoid facets formed thereon, terminating in an arcuate penetrating edge;

FIG. **13** is an isometric view of the penetrating tip of FIG. **12**, including hidden lines illustrating internal surface geometry of the tip;

FIG. **14** is a side view of the penetrating tip of FIG. **12**, including hidden lines illustrating internal surface geometry;

FIG. **15** is an end view of the penetrating tip of FIG. **12**, including hidden lines illustrating internal surface geometry;

FIG. **16** is a top view of the penetrating tip of FIG. **12**, including hidden lines illustrating internal surface geometry;

FIG. **17** is another embodiment of a penetrating tip in accordance with the invention having multiple facets on each side thereof, including ovoid facets, and terminating in an arcuate penetrating surface;

FIG. **18** is an isometric view of the penetrating tip of FIG. **17**, including hidden lines illustrating internal surface geometry of the tip;

FIG. **19** is a side view of the penetrating tip of FIG. **17**, including hidden lines illustrating internal surface geometry;

FIG. **20** is an end view of the penetrating tip of FIG. **17**, including hidden lines illustrating internal surface geometry;

FIG. **21** is a top view of the penetrating tip of FIG. **17**, including hidden lines illustrating internal surface geometry;

FIGS. **22**A-**22**F are views of a further embodiment of a penetrating tip constructed in accordance with the present invention;

FIGS. **23**A-**23**D are further views of the embodiment of FIG. **22**;

FIGS. **24**A-**24**E are views of still another embodiment of a penetrating tip constructed in accordance with the present invention;

FIGS. **25**A-**25**E are views of yet another embodiment of a penetrating tip constructed in accordance with the present invention; and

FIGS. **26**A-**26**E are views of another embodiment of a penetrating tip constructed in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings.

The present invention may be used for insertion of surgical access devices or other devices that require the puncture of biological tissue. The present invention is particularly suited for insertion of surgical access devices or cannulas (or "cannulae") through the abdominal wall of a patient, in order to provide a working channel through which a surgical procedure can be performed.

In accordance with the invention, as seen in FIG. **1**, a visualization trocar **100** is provided, which includes a handle **110**, a shaft **120** extending from the handle **110**, and a penetrating tip **130** arranged at the distal end of the shaft **120**. As illustrated, the trocar **100** can be used with an endoscope **190** having an eyepiece **193** at a distal end thereof, which receives images through an optical path from a lens (not shown) situated on the endoscope **190** near the penetrating tip **130**. Such images are typically transmitted by way of a transparent medium within the endoscope **190**, such as an optical shaft or one or more optical fibers. If it is desired that images be displayed on an external monitor, an attachment having an image sensor can be secured to the endoscope **190** on or in place of the eyepiece **193**. The endoscope **190** can further be provided with a secondary optical conduit **180**, which can transmit light to the penetrating tip **130**. Further in accordance with the invention, the trocar **100** can be provided with an integral endoscope, including all of the features thereof contained in one integral device.

Alternatively, if desired, an image sensor can be provided within the trocar **100** at the distal end thereof—in the shaft **120** or within the penetrating tip **130**. Accordingly, electrical rather than optical connections then extend through the shaft **120** to a display device, such as a video monitor.

Additionally a locking element **170** can be provided in the handle portion **110** of the trocar **100**. The locking element **170**, as embodied, engages the endoscope **190** passing through the handle **110**, to prevent at a minimum, relative axial movement between the trocar **100** and the endoscope **190**. Additionally, relative rotational movement can be inhibited, if desired.

The precise configuration of the trocar **100** itself can vary, and can include additional features, as needed or desired. Moreover, cannulae utilized with the trocar **100**, whether rigid or flexible, can include one or more demarcations thereon, which indicate the progress of insertion, and can therefore signal to the surgeon when the cannula has been inserted sufficiently.

Also, the geometry of the penetrating tip **130** can change as desired, as will become apparent through understanding of the various embodiments of penetrating tips, which are set forth hereinbelow. It should be noted that the term "trocar" is used herein to refer generally to an insertion device, which is capable of puncturing an anatomical structure, such as an abdominal wall, to insert a surgical access device or "port" to aid in performing a surgical procedure.

For the purposes of explanation and illustration, and not limitation, an isometric view of an exemplary embodiment of a penetrating tip in accordance with the invention is shown in FIG. **2** and is designated generally by reference number **200**. The penetrating tip **200** includes a body **210**, at its proximal end having a reduced-diameter portion **219**, and one or more rotation locking elements **217**, each of which interfaces with the shaft of a trocar (e.g., shaft **120** of trocar **100**). The reduced-diameter portion **219** is inserted into the shaft of a trocar, thereby enabling secure mutual engagement therebetween, while the rotation locking element(s) **217** engage a mating element, such as a groove, notch or recess in the shaft of the trocar, preventing relative rotation between the penetrating tip **200** and the trocar shaft. If, however, the tip **200** is manufactured integrally with a trocar, relative positioning can be achieved and maintained in another manner, such as integrally molding, insert molding, adhering, bonding or welding

the components by heat, solvent or friction, or by another suitable manufacturing technique.

The distal end of the penetrating tip **200** includes a distal taper **215** of the body **210**, and two opposed angled facets **220**, which are angled inwardly, approaching the penetrating edge **240** at the distal end of the tip **200**. The facets **220** are substantially planar in this embodiment, and are delimited partially by a change in contour indicated by arcuate contour interface **230** with the body **210**, and partially by the distal penetrating edge **240**. The facets **220** are angled, with respect to one another at an angle α (alpha). The angle α can be anywhere from about 5 degrees to about 90 degrees, inclusive, at any one-degree increment therebetween. In one embodiment, the angle α is about 30 degrees, and in another embodiment the angle α is about 40 degrees, for example.

In use, the tip **200** is inserted into a trocar, such as trocar **100** of FIG. **1**, or alternatively is manufactured integrally therewith. The tip **200** can be manufactured from any suitable material, but is preferably transparent, to allow a surgeon to view the layers of tissue through which the surgeon is penetrating. Such materials can include, for example, polycarbonate plastic, polymethyl methacrylate ("acrylic"), a vitreous material such as glass, or an optical crystal material. Accordingly, the surgeon is able to view the tissue through which the trocar and tip **200** are passing. The surgeon is able, therefore, to determine by the general appearance of the tissue, the point at which the tip **200** has penetrated to a sufficient depth. During an abdominal procedure, the depth will typically be a point at which the tip **200** has just entered the peritoneal cavity.

Further, in accordance with the invention, the tip **200** can be provided with any desired degree of sharpness. That is, the penetrating tip **240** can be formed to have a sharp point, a dissecting edge or can be rounded to any desired degree in order to provide a relatively blunt leading edge. When provided with a relatively blunt tip **240**, accidental injury to internal anatomical structures, such as intestines, can be reduced.

FIG. **3** is an isometric view of the tip of FIG. **2**, including hidden lines illustrating internal surface geometry of the tip **200**. As can be seen, an internal surface **350** is provided in the penetrating tip **200**. This internal surface **350** defines a space through which images can be taken. A visualization device (not shown) is preferably provided with trocars and penetrating tips in accordance with the invention, including that illustrated in FIGS. **2-6**. Various embodiments can be used to provide an image to the surgeon inserting the trocar. For example, an imaging device such as a CCD (charge-coupled device) can be provided in the trocar (e.g., trocar **100**) or in the penetrating tip (e.g., tip **200**), or alternatively connected thereto via an optical path, which can include, for example, one or more fiber-optic conduits. Such trocars can also be provided with illumination capability provided through the optical path.

The internal space defined by the internal surface **350** of the tip **200** includes surface features that correspond to features provided on the external surface of the tip **200**. As can be seen, an arcuate contour interface **353** and inner facet **352** correspond to the arcuate contour interface **230** and the facets **220** of the outer surface of the tip **200**. Moreover, an inner tip **354** of the space defined by the inner surface **350** corresponds to the penetrating edge **240** of the outer surface of the tip **200**. Such corresponding internal geometry can reduce distortion in an image obtained from the tip **200**. If desired, one or more lenses can be additionally provided within the tip **200**, to adjust, correct or direct images as needed.

FIGS. **4**, **5** and **6** are side, end and top views, respectively, of the tip **200** of FIGS. **2** and **3**, including hidden lines illustrating internal surface geometry of the tip **200**. Naturally, any of the features described in connection with any of the following embodiments can advantageously be applied to this embodiment.

FIGS. **7-11** illustrate an alternate embodiment of a penetrating tip **700** in accordance with the invention, having an arcuate penetrating surface **740**. As with the embodiment of FIGS. **2-6**, the tip **700** includes a body **710**, having at its proximal end a reduced-diameter portion **219**, and one or more rotation locking elements **217**. Naturally, if the tip **700** is manufactured integrally with a trocar, relative positioning can be achieved and maintained without such locking elements **217**.

The distal end of the penetrating tip **700** includes a distal taper **715** of the body **710**, and two opposed angled facets **720**, which are angled inwardly, approaching the cutting or dissecting edge **740** at the distal end of the tip **700**. Again, the facets **720** are delimited partially by an arcuate contour interface **730** with the body **210**, and partially by the distal edge **740**. In this embodiment, the facets **720** are convexly contoured, rather than being planar, which can best be seen in the side view of FIG. **9**. The facets **720** are angled, with respect to one another at an angle α (alpha). The angle α can be, for example, anywhere from about 5 degrees to about 80 degrees.

FIG. **8** is an isometric view of the tip **700** of FIG. **7**, including hidden lines illustrating internal surface geometry of the tip **700**. As with the foregoing embodiment of FIGS. **2-6**, an internal surface **750** is formed within the tip **700**, which includes surface features corresponding to features of the outer surface of the tip **700**. Alternatively, any of the embodiments set forth herein can include a solid tip. Preferably, however, such tip will include optical elements to enable adequate optical transmission of images from the distal end of the tip **700**. Alternatively still, if an imaging device, such as a CCD is provided within the body **710** of the tip **700** at an appropriate location, such as just proximal of the facet **720**, an adequate image can be obtained regardless of the optical characteristics of the remainder of the tip **700**.

FIGS. **9-11** are side, end and top views of the tip **700** of FIGS. **7-8**, including hidden lines illustrating internal surface geometry. Naturally, any of the features described in connection with any other embodiment set forth herein can advantageously be applied to this embodiment.

FIGS. **12-16** illustrate a further embodiment of a penetrating tip, designated generally with reference number **1200**, in accordance with the invention. The tip **1200** includes ovoid facets **1120** formed thereon, terminating in an arcuate cutting or dissecting surface **1240**. The tip **1200** is similar in many respects to the foregoing embodiments. However, the ovoid facets **1220** result in a reduced profile for insertion. That is, instead of the relatively wide surfaces **240**, **740** of the above-described tips **200**, **700**, respectively, the cutting or dissecting edge **1240**, at the distal end of the ovoid facets **1220**, is relatively narrow. This aspect of the tip **1200**, can facilitate initial insertion by reducing the force necessary to puncture the abdominal wall. The tapered region **1215** of the body **1210**, helps widen the initial incision, as the tip **1200** advances through the patient's abdominal wall. The ovoid facets **1220** can be convex or planar, as desired, and are delimited by the penetrating edge **1240**, and the contour interface **1230**, where the contour of the tip **1200** transitions from the facet **1220** to the relatively cylindrical body **1210**. Moreover, the facets **1220** are angled with respect to one another at an angle α (alpha). The angle α can be anywhere from about 5 degrees to about 80 degrees, for example.

FIG. **13** is an isometric view of the tip **1200** of FIG. **12**, including hidden lines illustrating internal surface geometry of the tip **1200**. In this view, the internal surface **1350** of the tip **1200** is visible. As with foregoing embodiments, the internal surface **1350** can include features that correspond to features of the outer surface of the tip **1200**. For example, the tip **1200** can include a contour interface **1353** corresponding to the contour interface **1230** of the outer surface of the tip **1200**, and can include an inner facet **1352** corresponding to the facet **1220** on the outer surface of the tip **1200**.

FIGS. **14-16** are side, end and top views, respectively, of the tip of FIGS. **12-13**, including hidden lines illustrating internal surface geometry. Naturally, any of the features described in connection with any other embodiment set forth herein can advantageously be applied to this embodiment.

FIG. **17-21** illustrate another embodiment of a penetrating tip **1700** constructed in accordance with the invention having multiple facets **1721**, **1723**, **1725** on each side thereof, including ovoid facets **1721**, and terminating in an arcuate cutting or dissecting surface **1740**, similar to the embodiment of FIGS. **7-11**. The penetrating tip **1700** includes a body **1710**, at its proximal end having a reduced-diameter portion **219**, and one or more rotation locking elements **217**, as with the foregoing embodiments.

The distal end of the penetrating tip **1700** includes a distal taper **1715** of the body **1710**, and opposed angled facets **1721**, **1723**, **1725**, which are angled inwardly, approaching the penetrating edge **1740** at the distal end of the penetrating tip **1700**. The facets **1721**, **1723**, **1725** can be either convex or substantially planar. As illustrated, the facets include a substantially planar facet **1721**, and convex facets **1723**, **1725**, the convexity of which is best seen, for example, in the side view of FIG. **19**. The facets **1721**, **1723**, **1725** are delimited on one side by the contour interface **1730** and at the other side by the cutting or dissecting edge **1740**. The change in contours among adjacent facets is defined therebetween at a contour interface indicated by line **1732**. The facets **1721** of opposite sides of the penetrating tip **1700** are angled, with respect to one another at an angle α (alpha). The angle α can be anywhere from about 5 degrees to about 80 degrees, at any one degree increment therebetween, for example.

Naturally, the precise configuration of the facets **1721**, **1723**, **1725** in this and other embodiments set forth herein can be altered as needed. As can be seen in FIG. **18**, the contour interface **1730** includes a corresponding inner contour interface **1853** defined on the inner surface **1850** of the tip **1700**, as part of a generally corresponding overall shape.

FIGS. **19-21** are side, end and top views, respectively of the tip **1700** of FIGS. **17** and **18**, including hidden lines illustrating internal surface geometry.

For the purpose of further illustration and not limitation, FIGS. **22**A-**22**F and **23**A-D represent further embodiments of a tip **2200** made in accordance with the invention. FIG. **22**A depicts a lengthwise view of tip **2200** along one of two opposing substantially ovoid main facets **2220** that converge to a distal dissecting edge **2210**. As depicted, facets **2220** are substantially flat, as opposed to concave or convex. Additional smaller facets **2225** are defined between the main facets **2220**. As depicted, the intervening facets **2225** are generally elongate concave formations or grooves. It will be appreciated that each of the facets **2220**, **2225** may be substantially flat, convex or concave, as desired. FIG. **22**B depicts an end view of tip **2200**, showing the manner in which all four facets converge and taper to edge **2210**. FIG. **22**C depicts a lengthwise view of tip **2200** illustrating the shape of facet **2225**. FIG. **22**D illustrates a cross sectional view of tip **2200** taken along line "A-A" in FIG. **22**C. FIG. **22**E illustrates a cross sectional view of tip **2200** taken along line "B-B" in FIG. **22**A. FIG. **22**F illustrates an enlarged cross sectional view of tip **2200** illustrating a locking feature discussed below. FIGS. **23**A-C depict similar illustrations of tip **2200** showing the interior surfaces of tip **2200** in broken lines. FIG. **23**D depicts an isometric view of tip **2200**.

As depicted, tip **2200** defines a hollow interior **2250** bound by a plurality of inner surfaces **2260**. A locking feature **2230**, if desired, may be provided to facilitate attachment of tip **2200** to a trocar shaft, as described herein. If desired, the tip **2200** may be fully transparent or may include one or more opaque, darkened or otherwise visually obscured regions, such as in the distal region **240** of the tip **2200**, proximate the dissecting edge **2210** in region **2240**. Such regions are illustrated in the embodiments of FIGS. **24-26** and discussed in further detail below, and can improve visibility of the anatomy being penetrated by reducing glare from stray light entering the tip **2200**. As will be appreciated by those of skill in the art, the integral dissecting edge, whether blunt or otherwise, the inwardly tapered opposed planar facets and the opaque distal tip portion of the penetrating tip cooperate to define a continuous outer surface without any openings therethrough. Moreover, as is clearly evident from FIGS. **24-26**. the opaque region is preferably adapted to extend around the entire periphery of the tip from a portion proximal to the distal end of the tip to and including the distal end of the tip.

The opaque distal region of the body can minimize glare by reducing errant internal reflections within the tip **2200**. Alternatively or additionally, the opaque distal region, which can be colored and in contrast with the remainder of the body of the penetrating tip, can be provided in a manner such that it functions as an indicator or gauge. The term opaque, as used herein, generally refers to an item that substantially inhibits transmission of light. The opaque distal region can be black, gray, blue, white, red, green, purple, pink, yellow, orange or any color desired. Alternatively, if desired, the tip can be translucent and can be clear or have a color imparted thereon. Moreover, the degree of translucidity can be selected as desired, and thus may still act to reduce glare and/or to serve as a gauge or guide. It is also conceived that providing the entire tip or only the distal region **2240** of the tip **2200** with a particular color can serve to act as an optical filter to enhance images obtained therethrough.

As an example, when the colored or obscured distal region **2240** is provided in a trocar used in a surgery, a patient's abdomen can be insufflated normally, and an endoscope inserted through the abdominal wall in a conventional manner. Then, when a trocar having a penetrating tip constructed in accordance with the invention is inserted through the abdominal wall, upon reaching the peritoneum, the distal region (having a color, or other feature), becomes readily visible to the surgeon. This is possible only if the surgeon views the procedure through the endoscope already inserted through the abdominal wall. This, however, may require two separate people to view two separate endoscopes.

By way of further example, FIGS. **24**A-**24**D depict still another embodiment of a tip **2400** made in accordance with the present invention having a plurality of facets **2420**, **2425** similar to the embodiment of FIGS. **22-23** and defining a dissecting edge **2410**. More particularly, facets **2420** are generally flat surfaces, and facets **2425** are generally concave grooves. It will be appreciated that the shape of facets **2420**, **2425** may be modified, as desired to include convex and/or concave surfaces. Locking features **2430** are further provided to facilitate a connection with a trocar tube. Moreover, a distal region **2440** is provided that is generally pyramidal shaped to ease penetration in tissue. As depicted, the distal region **2440**

can be darkened, opaque or otherwise obscured, such as by a coating applied thereto, for example, or in another manner.

Such an obscured or opaque region (e.g., **2440**) can help reduce the effects of internal reflections in the tip **2400**, thus improving viewing. It will be appreciated that all tips disclosed herein may be provided with such an opaque, or otherwise obscured distal region, as desired. The opaque or obscured region may be made by depositing an opaque material on the surface of the tip **2400** in region **2440**, such as by screen printing or painting. Moreover, such a region may be provided by treating the surface of the tip to be obscured such as by roughening to substantially prevent light from passing through the region **2440**. Alternatively, the obscured region **2440** can be separately formed of an opaque material and combined, by insert molding or other suitable manufacturing technique, with the remaining material of the tip **2400**. Alternatively still, the region **2440** may be treated by providing a second material within the material of the tip **2400** in the region **2440** in order to darken the region **2440**. The tip **2400** is preferably hollow as with the foregoing embodiments, in order to ease image transmission and to accommodate an endoscope therein for transmitting and receiving light.

FIGS. **25**A-**25**D illustrate still another embodiment of a tip **2500** made in accordance with the invention. As depicted, the tip **2500** includes two facets **2520** similar to the embodiments of FIGS. **22-24**. Tip **2500** further includes a generally pyramidal distal region **2540** that is opaque or otherwise obscured. It will be understood that the entirety of tip **2500** may alternatively be transparent, as desired. The distal region **2540** terminates in a tissue separating edge **2510** and locking feature **2530** as with other embodiments described herein. As depicted, tip **2500** further includes two longitudinal depressions **2545** formed therein. Depressions **2545** may facilitate advancement of tip **2500** through tissue by lowering resistance. As depicted, depressions **2545** may be obscured and/or provided with an opaque coating to improve the optical performance of tip **2500**. Moreover, the tip **2500** is preferably hollow to accommodate an endoscope, and can be provided with optical features to enhance images obtained therefrom.

By way of still further example, FIGS. **26**A-**26**E illustrate yet another embodiment of a tip **2600** made in accordance with the invention. Tip **2600** includes a plurality of facets **2620** (four identical facets, as depicted) that join each other at edges **2622** and taper to form a distal region **2640** terminating at a penetrating edge **2610**. As depicted, distal region **2640** is obscured or opaque, but may be transparent if desired. A locking feature **2630** may further be provided, if desired. As most clearly illustrated in FIG. **26**E, the cross section of tip **2600** closely resembles a rectangle with inwardly bowed sides. Such a geometry effectively forms four concave facets **2620** with a reduced cross sectional profile that can facilitate advancement of tip **2600** through tissue by lowering insertion resistance. Tip **2600** is preferably hollow to accommodate an endoscope.

Images can be output from the aforementioned devices—that is in the penetrating tips or in the trocars, for example. The images can be displayed for the surgeon on a monitor arranged in a convenient location. If so-desired, a monitor can be provided at and integrated with the proximal end of the trocar itself, so as to enhance the perception and ergonomic aspects of trocars in accordance with the invention. If so-equipped, the proximal end of the trocar can be configured so as to include one or more integral handles to facilitate gripping of the trocar by the surgeon. Moreover, if so desired, images can be automatically manipulated in real time by a computer, prior to display, so as to reduce or eliminate any distortion, color imbalance or other optical aberrations which may be present in the raw image output from the image sensor.

Penetrating tips and trocars in accordance with the invention can be used to create an opening in an anatomical structure of a patient, such in the patient's abdominal wall. The opening can be used to provide access or any of a variety of instruments, such as, for example, a feeding tube. However, it is particularly envisioned, that devices constructed in accordance with the invention will be used to insert surgical access devices, such as access ports and cannulas, which maintain the opening formed by a trocar and therefore provide easy access to a surgical cavity. Some example access devices are set forth in U.S. patent application Ser. No. 11/517,929, filed Sep. 8, 2006 entitled "Trocar Assembly with Pneumatic Sealing," which application is incorporated herein by reference, in its entirety. Access devices described in the aforementioned application include various types of seals to inhibit escape of insufflation gas from a patient's peritoneal cavity during a surgical procedure. Additionally, devices constructed in accordance with the invention can be used to insert flexible access devices, such as those set forth in the application entitled "Elastically Deformable Surgical Access Device" U.S. patent application Ser. No. 11/544,856, filed Oct. 6, 2006, which application is also incorporated herein by reference in its entirety. If used with such elastically deformable surgical access devices, engagement elements can be provided on the trocar or the penetrating tip to enable engagement with such access device.

Following preparation of the patient, a trocar having a tip in accordance with the invention is used to pierce the abdominal wall of the patient. The surgeon is able to view the tissue being penetrated by the penetrating tip through any of the aforementioned means, such as through a video monitor. Typically, a surgical access device, as those described above, will be inserted simultaneously through the opening created by the trocar. Thus, prior to insertion, the trocar with the penetrating tip is inserted through the access device such that the penetrating tip protrudes from the end of the access port, and the penetrating tip, surrounded by the access port, is inserted through the abdominal wall. In one technique, a scalpel is used to make an incision through the skin, and the penetrating tip with the trocar and access port is inserted through the remaining layers of tissue into the abdominal wall. The trocar is then removed, leaving the surgical access device in place in order to carry out the prescribed surgical procedure.

Further, the present invention encompasses methods of use of the devices described herein. For example, the present invention includes methods of use of penetrating tips described herein, in combination with insertion devices, such as trocars or obturators, and surgical access devices, such as cannulas.

Further it is envisioned that the present invention can relate to a kit having one or more of a penetrating tip in accordance with the invention, a surgical access device, such as a cannula, and an insertion device, such as a trocar or obturator.

It will be apparent to those skilled in the art that various modifications and variations can be made to devices of the present invention without departing from the spirit or scope of the invention.

What is claimed is:

1. A penetrating tip for a surgical trocar, the penetrating tip comprising:

(a) a generally transparent body having opposed proximal and distal ends, the body including an opaque distal tip portion having a generally pyramidal shape configured

to ease penetration through tissue, wherein the opacity of the distal tip portion helps to reduce internal reflections within the tip;

(b) an integral dissecting edge arranged at the distal end of the body;

(c) a pair of inwardly tapered opposed planar facets formed in the body, converging with one another at the integral dissecting edge; and

(d) a pair of opposed curved facets formed in the body, separating the pair of inwardly tapered opposed planar facets from one another and extending distally toward the integral dissecting edge.

2. The penetrating tip of claim **1**, the tip further comprising an expanded-diameter region for engaging a surgical access device.

3. The penetrating tip of claim **1**, wherein the opposed curved facets are concave grooves.

4. The penetrating tip of claim **1**, wherein the opposed inwardly tapered planar facets are provided on the tip at about a 20 degree angle with respect to one another.

5. The penetrating tip of claim **1**, wherein the opposed inwardly tapered planar facets are provided on the tip at about a 30 degree angle with respect to one another.

6. The penetrating tip of claim **1**, wherein the integral dissecting edge is substantially straight in configuration.

7. The penetrating tip of claim **1**, wherein a locking element is provided on the body for engaging an obturator.

8. The penetrating tip of claim **1**, wherein the tip further includes an inner optical surface configured so as to minimize distortion of images taken through the penetrating tip.

9. The penetrating tip of claim **1**, wherein the tip consists of a plastic material.

10. The penetrating tip of claim **1**, wherein the tip is formed of polycarbonate plastic.

11. The penetrating tip of claim **1**, wherein the tip is formed of polymethyl methacrylate.

12. A surgical trocar comprising:

(a) a handle;

(b) an elongated shaft extending distally from the handle; and

(c) a penetrating tip operatively associated with a distal end portion of the elongated shaft, the penetrating tip including:

(i) a generally transparent body having proximal and distal ends, the body having an opaque distal tip portion having a generally pyramidal shape configured to ease penetration through tissue, wherein the opacity of the distal tip portion helps to reduce internal reflections within the tip;

(ii) an integral dissecting edge arranged at the distal end of the body;

(iii) a pair of inwardly tapered opposed planar facets formed in the body, converging with one another at the integral dissecting edge; and

(iv) a pair of opposed curved facets formed in the body, separating the pair of inwardly tapered opposed planar facets from one another and extending distally toward the integral dissecting edge.

13. The surgical trocar of claim **12**, further comprising an optical path extending from the tip to an imaging device.

14. The surgical trocar of claim **13**, wherein the imaging device is a CCD sensor.

15. The surgical trocar of claim **13**, wherein the imaging device is an optical eyepiece.

16. The surgical trocar of claim **13**, wherein the imaging device is provided in the shaft of the surgical trocar.

17. The surgical trocar of claim **13**, wherein the imaging device is provided external to the surgical trocar.

18. The surgical trocar of claim **12**, further comprising an access device configured and dimensioned to receive the shaft of the trocar such that the penetrating tip protrudes from the end of the access device.

19. The penetrating tip of claim **1**, wherein the opaque distal tip portion has an opaque coating applied thereto.

20. The penetrating tip of claim **19**, wherein the opaque coating includes paint.

21. The penetrating tip of claim **19**, wherein the opaque coating is screen printed onto the distal tip portion.

22. The penetrating tip of claim **1**, wherein the tip defines an enclosed interior therein disposed between the inwardly tapered opposed planar facets.

23. The surgical trocar of claim **12**, wherein the integral dissecting edge is blunt such that the tip is adapted and configured to prevent accidental injury to internal anatomical structures.

24. The penetrating tip of claim **1**, wherein the integral dissecting edge is blunt.

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